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NOTES AND COMMENTS.

Life of Cast-Iron Pipe.

Controversy has often raged round the respective merits of cast iron and steel tubes for pipe lines, though on the question of length of life cast iron seems to be premier. According to a writer in the "Mining and Scientific Press," cast-iron, especially in the form of pipe, seems to last longer than any other form of iron. Some remarkable records have been reported. There are records of pipe in use in Europe for over 200 years. In the early years of American railways, water-service was given with pipes of less than 3 in. diameter and the use of cast-iron pipe in consequence was limited to cases where 3-in. or larger pipe was used. The life of several of these lines has been traced to the present time. The most interesting is that of a pipe-line laid at Centralia, Illinois, in 1855. This was of 4-in. cast-iron pipe about 10,000 ft. long. After twelve years of service it became inadequate for the increased consumption, and upon examination it was found to be heavily furred inside. Efforts were made to improve its capacity by cleaning it and relaying a part of it with clean-out boxes at intervals of 100 ft. This provided only a temporary relief, and the following year about 5,000 ft. of the line were taken up and relaid with 8-in. pipe which is still in service after being in the ground nearly 50 years. The 4-in. pipe taken up at Centralia was relaid in 1868 at Ramsey, Illinois, where it remained in service until 1903, when it again became too small for the demand and was replaced by 6-in. pipe. Since that time the old 4-in. pipe has been used at various places, principally as drains. Another installation of which authentic records are available is one of 7,500 ft. of 4-in. cast-iron pipe at Little Wabash river, laid in 1857. This remained in service until July, 1893, when it was replaced. The old pipe was stored at Centralia until 1895, when portions of it were relaid at that place and at Effingham and at Big Muddy. The installations at the last-named places have since been removed, but the pipe at Centralia is still in service. The pipe had apparently never been painted.

Fused Bauxite for Furnaces.

A recent issue of "La Cérambique" gives the following particulars of the late M. Lecesne's method of preparing bauxite for furnace lining and crucibles: A mixture is prepared of one part of anthracite and three parts of bauxite of an average composition of about 60 per cent. alumina, 10 per cent. iron sesqui-oxide, and 10 per cent. silica, moist as it comes from the quarry. The mass is charged into a furnace lined with refractory material, preferably fused bauxite, and previously heated with anthracite, air being blown through the charge at an initial pressure of about 40 in. water gauge, rising afterward, according to the depth of the charge, though 160 in. pressure is the usual maximum. The temperature rises quickly and the sudden vaporising of the water in the bauxite causes it to break up and to granulate, while the aluminium carbide produced burns and raises the charge to a point at which the silica is volatilised, and the iron, reduced by the action, is expelled by the air-blast as a shower of sparks. The air-blast is continued in order to burn off the surplus

anthracite and cool the fused mass, which can then be discharged from the furnace and ground, mixed with crude or calcined bauxite as a binder, moulded, dried, and fired in the same way as calcined bauxite. If the fusion is performed quickly, say in about three hours, the resulting mass will be highly porous, besides containing a sufficiency of unconsumed anthracite to facilitate grinding and briquetting. The fused bauxite will give a refractory material (corindite) stated to be capable of withstanding a temperature of over 2,000 deg. C., if mixed with some of the same material freed from iron by magnetic separation, and with water and quicklime, the latter forming a binder of silicate of lime. Mixed with bauxite the product is hard but porous, and forms a suitable lining for reverberatory or other furnaces heated with liquid or gaseous fuel.

British Foundrymen's Association.

Branch Programmes.

Lancashire Branch.—President, Mr. S. Roe, Oldham; *Vice-Presidents*, Mr. W. H. Meadowcroft, Newton Heath, and Mr. J. Haigh, Wakefield; *Secretary*, Mr. J. Hogg, 100, Rose Grove Lane, Rose Grove, Burnley.

October 5, 1918.—Presidential Address, by Mr. S. Roe.

November 2.—"Electric Welding of Castings," by Lieut.-Commr. Jackson.

December 7.—"The Smelting of Cleveland Ironstone," by Mr. S. G. Smith.

January 11, 1919.—"A Brass-foundry Problem; with Notes on the Melting of Non-Ferrous Metals," by Mr. G. C. Swift.

February 1.—"Our Deficiencies in Treatment of the Foundry Lad: suggested Causes and Remedy," by Mr. S. P. Howden, B.Sc.

March 1.—"Practice Notes on some Jolt-ramming Jobs," by Mr. B. Hird.

April 5.—"Technical Considerations in Foundry Work," by Mr. J. Riley, M.Sc.

May 3.—Annual Business Meeting; and "The Keeping of Cupola Records," by Mr. J. Haigh.

The meetings are held in the Municipal School of Technology, Manchester, at 4 p.m.

Scottish Branch.—President, Mr. R. R. McGowan, Glasgow; *Vice-Presidents*, Mr. Wm. Bell and Mr. A. Fraser; *Secretary*, Mr. J. Macfarlane, 3, Sharrocks Street, Ibrox, Glasgow.

October 12, 1918.—"Education and Industry," by Mr. R. R. McGowan.

November 11.—"An Impeller Casing in Loam," by Mr. T. Bell.

December 12.—"Notes on Semi-steel Practice," by Mr. M. Riddell.

January 11, 1919.—"Cupola Notes," by Mr. J. Logan.

February 2.—"Additional Notes on the Influence of some Special Constituents on Cast Iron," by Prof. A. Campion, F.I.C., F.C.S.

March 1.—"Brass Founding," by Mr. W. Tonagh.

March 22.—Annual Business Meeting; and "Moulding a Propeller," by Mr. W. Bell.

Meetings are held in the Royal Technical College, Glasgow.

East Midlands Branch.—President, Mr. R. T. Russell, Derby; *Vice-Presidents*, Mr. W. G. Haslam and Mr. H. H. Moore; *Secretary*, Mr. H. Bunting, 17, Marcus Street, Derby.

October 19, 1918.—"The Necessity of an Information Bureau for Foundrymen," by Mr. R. Buchanan.

November 16.—"The Pyrometer in the Foundry; and the Stability of Alloys as affected by Electro-thermal Relations," by Mr. J. Drummond Paton, M.I.M.E., A.M.I.E.E.

January 18, 1919.—"Some Notes on Jolt-ramming Moulding Machines," by Mr. H. Pemberton.

February 15.—"Difficulties underlying Malleable Iron Casting," by Mr. F. Cooke.

March 1.—Paper by Mr. A. L. Key.

March 22.—Open discussion on Foundry Problems; Annual Business Meeting.

Birmingham Branch.—President, Mr. J. J. Howell, Birmingham; *Vice-Presidents*, Mr. A. Harley and Mr. E. N. Wright; *Secretary*, Mr. F. E. Shearman, 63, Summerfield Crescent, Edgbaston.

October 26, 1918.—Presidential Address by Mr. J. J. Howell.

November 7.—"Research in Malleable Cast Iron," by Prof. T. Turner. (Joint meeting with Birmingham Metallurgical Society.)

November 23.—"Permanent Moulds," by Mr. E. H. Broughall. (Joint meeting with Staffs. Iron and Steel Institute.)

December 7.—"Plaster Patterns in an Engineering Shop," by Mr. C. Robinson.

January 25, 1919.—"Mechanical Tests," by Mr. F. C. H. Lantsbury. (Joint meeting with Staffs. Iron and Steel Institute.)

February 22.—"The Foundry Service from an Engineering Point of View," by Mr. A. Berriman. (Meeting at Coventry.)

March 22.—"Electric Furnaces," by Mr. J. H. Stansbie. (Joint meeting with Birmingham Metallurgical Society.)

April 12.—"A Retrospect of the Non-ferrous Trade," by Mr. J. Gaunt.

Meetings are held at the Municipal Technical School, Suffolk Street, Birmingham, at 6.30 p.m.

New Peterborough Branch.

We are glad to announce that a new Branch of the Association was inaugurated last month at Peterborough, and promises to contribute very considerably to the activities of the Association in that district. Its formation was largely due to the initiative and energy of Mr. Ben Hird, who has been elected Branch Secretary. The membership has already numbered about 50, and promises to increase rapidly. The following gentlemen have been elected to office:—President, Commdt. C. W. Bryant; Vice-Presidents, Mr. A. J. S. Perkins and Mr. S. W. Hanson; Branch Committee, Messrs. J. Ewen, J. E. Pointon, J. Butler, Robt. True, C. Stott, F. J. Dent, —, Baker, G. Barker, and W. Dobbs. The Secretary's address is:—Mr. Ben Hird, 1, G.W. Station Road, Peterborough.

The first meeting of the Branch will be held on October 12, when a discussion will be held on "Pellets in Iron Castings."

A Method for the Prevention of Growth in Grey Cast Iron.*

By J. E. Hurst (Acton).

The phenomenon of growth or expansion of grey cast iron when subjected to repeated heatings in an oxidising atmosphere has been shown to be due to the increase in volume consequent upon the internal oxidation of the various constituents by means of the gradual penetration of the oxidising gases into the centre of the grey cast-iron mass; while it has been shown that the whole of the constituent silicon is comparatively rapidly completely oxidised, and the total growth experienced is roughly proportional to the extent of silicon present in the original iron. The primary cause of growth is the presence of the free graphite plates which allow of the entry and penetration of the oxidising gases into the interior of the iron. It has been experimentally shown that in those white cast irons in which free graphite is absent, the total expansion is almost negligible, and for the most part can be accounted for by the precipitation of free carbon in the nodular annealing carbon form.

It is of considerable importance to note that malleable cast irons in which the free carbon exists in the nodular form of annealing carbon do not grow. This is the result of the fact that the graphite in these irons does not present a continuous path for the penetration of the oxidising gases into the interior of the mass.

On these grounds, therefore, it will be readily appreciated that any method whereby the entrance of the oxidising gases into the interior of the casting is prevented will simultaneously prevent growth. Methods in which the outside surface of the material is coated with a layer of impervious refractory enamel readily suggest themselves as a means whereby the entry of the oxidising gases may be prevented. Apart from the difficulty of obtaining a suitable enamel, such methods would entail many disadvantages in the majority of circumstances.

The removal of the free graphite from the exterior surface layers of the cast iron would appear to be an ideal method for preventing the penetration of the oxidising gases. Such a method would amount to the production of a skin or "case" of decarbonised material round the cast iron, which would effectually prevent the entry of the oxidising gases. By this means growth would be prevented, and the use of alternative white irons which involve difficulties in machining would be obviated.

An example has been recorded in the shape of a length of grey cast-iron water pipe, 4 in. in diameter and about 3-16 in. in thickness, which was prevented from growing by the formation of a protecting "case." The pipe was repeatedly maintained at a temperature in the region of 800 deg. C. and 900 deg. C. alternatively for a considerable period in a strongly oxidising furnace atmosphere. The chemical composition of the cast iron was as follows:—Combined carbon, nil; total carbon, 2.20 per cent. (by combustion); graphite, 2.20 per cent.; silicon, 2.66 per cent.; manganese, 0.46 per cent.; sulphur, 0.096 per cent.; phosphorus, 0.95 per cent. This analysis was taken from the material after exposure to the heat, the low total carbon content being due to the unavoidable inclusion of drillings from the decarbonised portion of the iron. It was found on examination of the silica precipitate from the silicon estimation that the whole of this precipitate was quite white and flocculent. This is confirmatory evidence of the absence of internal oxidation.

On fracturing the iron, the inner core of grey graphitic iron, surrounded on both sides by a "case" having a bright steely fracture, was rendered plainly visible. In photomicrographs taken from a section cut from this pipe, the completeness of the decarburisation and the almost entire removal of the graphite plates were clearly shown. It was extremely interesting and important to note the existence of the phosphide eutectic constituent in the decarbonised case. This constituent was evenly distributed throughout the original material. In the interior of the heat-treated specimen the graphite appeared to exist in a finely divided, possibly annealing, carbon form. The presence of holes was also noted, as would be expected as a consequence of the removal of a portion of the phosphide constituent.

Previous to exposure to heat the pipe was heavily coated with a thick scale of rust (hydrated ferric oxide). It is considered that the initial presence of this scale has largely contributed to the decarbonisation. In his repeat experiments the author has met with success by prolonged annealing in this material. The possibility of the complete removal of the graphite plates and the entire absence of spaces where the graphite originally existed when heat treated under oxidising conditions was clearly proved by the photomicrographs. So far as the author's knowledge goes, this observation is entirely new.

The possible methods by which graphite might be removed without the subsequent production of cavities in the metal may be briefly summarised as follows:—(1) Superficial decarburisation and the oxidation of the graphite followed by the liquation of the phosphide eutectic into the remaining cavities. (2) At temperatures of over 900 deg. C. within the range of temperature to which the above-mentioned samples have been exposed (900 deg. C. to 1,000 deg. C.) it is certain that a considerable portion of the graphite is redissolved, forming the austenite solid solution. In those irons containing considerable quantities of phosphorus the conditions are considerably more complex, but there is every probability of the resolution of the graphite taking place with the production of complex ternary constituents. Under these circumstances the possibility of the removal of the graphite with the entire absence of holes will be appreciated.

Further investigation is necessary before a complete explanation of the mechanism of the surface decarburisation can be satisfactorily given. It appears extremely probable in this particular case that decarburisation of the superficial layers of the

*Read, September 12, before the Iron and Steel Institute.

austenite in direct contact with the heavy scale of ferric oxide primarily takes place. The austenite solid solution, in addition to the carbon originally existing as combined carbon, possibly contains some of the graphite dissolved, and in this manner the graphite is removed from a superficial layer and the entry of the oxidising gases prevented.

The original analyses of the above-mentioned specimens are not known, but it is legitimate to assume that the original carbon contents of this class of casting would be as follows :—Total carbon, 3.25 per cent.; graphite, 2.75 per cent.; combined carbon, 0.50 per cent. It will be seen, therefore, that about 1 per cent. of the total carbon is removed by oxidation, and this is very probably all removed at the high temperature, whilst in the austenite condition, by the gradual diffusion of the austenite towards the decarbonised portions. This assumption is borne out by heat-treatment experiments on a similar class of iron, in which it has been shown that when quenched from a temperature of 900 deg. C. to 950 deg. C., over 1 per cent. of carbon can be retained in the dissolved austenite form. The presence of carbon in the annealing carbon form noticed in the core of the specimen was also additional proof of the fact that the graphite had been redissolved and reprecipitated in this form on slow cooling.

It is of considerable importance to note the diffusion of the phosphorus in this particular sample. As seen from a photograph, the whole of the decarbonised case was entirely unaffected by the reagent, showing that, in addition to the binary eutectic, a considerable amount of the phosphorus of the sample existed in solid solution in the decarbonised case. It is considered in this particular instance that the diffusion of the phosphide is for the most part a secondary phenomenon. The phosphide will commence to dissolve as the concentration of the austenite solid solution is gradually reduced, and, as has been shown by Dr. Stead, the dissolved phosphide will tend to diffuse to the decarbonised portions (*i.e.*, the outside edges), and will tend to become concentrated in those portions.

It will be readily appreciated that the production of a decarbonised case around cast-iron articles in this manner will be of considerable service in the prevention of growth under many circumstances. It has already been suggested that this method should find application in the protection from growth of dies and permanent moulds for iron and non-ferrous metals. Other important uses suggest themselves, such as the protection of valve seatings and valve guides in internal-combustion engines. For this purpose further experimental work will be necessary to accurately determine the conditions under which this graphite can best be removed. The author has several permanent moulds which have been protected in this manner by annealing at a temperature of 900 deg. C. to 950 deg. C. in ordinary brown rust (oxide of iron) for a period of 72 hours. The results have also been considerably improved by raising the annealing temperature to 975 deg. C. to 1,000 deg. C. Troubles, however, have been experienced in these cases through distortion. At this high temperature (from the preliminary investigations already made) the removal of the graphite would appear to be brought about through the formation of the ternary eutectic of iron, phosphorus, and carbon, and in this respect is somewhat different to the above-mentioned case.

Discussion.

Dr. W. H. Hatfield was sorry to say that he was in entire disagreement with the author. He looked with great disfavour upon any suggestion of submitting grey cast iron to the treatment which the author proposed. He would remind the author that the growth of cast iron was induced by alternate exposure to temperatures below those stated in the Paper. The subject had been extremely well dealt with by Professor Carpenter and Professor Rugan in papers written by them during the last few years, and if the author had carefully referred to their work he believed he would have given his investigations a great deal more consideration before presenting them to the Institute. He thought Dr. Stead would confirm his statement that if grey cast iron were exposed to the high temperatures mentioned by the author it would be absolutely ruinous. If, by the growth of cast iron, its properties were modified in the way indicated by Professor Carpenter, it was inevitable that at the temperatures dealt with a decarburised skin would be produced. Further than that, it had not the homogeneous skin of ferrite which the author assumed. The weakness left by the graphitic plates still remained

Mr. Young was in disagreement with the statements in which the author apparently accounted for the whole of the growth by the penetration of the oxidising gases through the graphite. The statement was made that the total growth was roughly proportional to the extent of silicon present in the original iron. The total growth could be altered in other ways than by altering the silicon; other elements could be added which would alter the growth and yet the silicon remain the same. The penetration of oxidising gases, or of any gas, did not seem to him to be due only to graphite. He desired to ask the author what was the depth or thickness of his protecting case? The statement was also made that :—"It was found on examination of the silica precipitate from the silicon estimation that the whole of this precipitate was quite white and flocculent. This is confirmatory evidence of the absence of internal oxidation." Previous to that the author made the statement that he could not get the total carbon content right owing to the unavoidable inclusion of drillings from the decarbonised portion of the iron. Personally, he estimated that about 0.88 of the silicon would be in the decarbonised portion, and it seemed to him that the confirmatory evidence did not exist of the absence of internal oxidation. The author further stated there was no doubt that the heat-treated sample was somewhat more brittle than the normal sample. That was a very important point. Later in the Paper the author stated :—"The possible methods by which graphite might be removed without the subsequent production of cavities in the metal are briefly summarised below : (1) Superficial decarburisation and the oxidation of the graphite, followed by the liquation of the phosphide eutectic into the remaining cavities." From the short study he had made of the Paper, he understood the author thought it was a good idea that the phosphide eutectic should fill up the cavities of the graphite. On the other hand, in the Paper read by Mr Hurst a year ago before the Institute, he described phosphorus as being unnecessary and prejudicial to growth, and that it should be reduced to as large an extent as possible. In the present Paper he seemed to have arrived at an exactly opposite conclusion.

Dr. J. E. Stead thought Dr. Hatfield would support him in the statement that, on annealing cast iron in a malleable furnace, a ring was obtained at a little distance from the outside envelope which had very much the appearance of phosphide of iron; in fact, he erroneously mistook it for phosphide of iron, but on actually making an analysis and separating the material he found it was carbide. Outside of that ring, however, the greater part of the phosphorus was in solid solution. The carbon had been removed from

the outside ring, which corresponded exactly with the ring described by the author. The phosphorus was in solid solution; there was no free phosphide; it had all passed into solid solution. So far as that was concerned, it confirmed what the author had stated. He subjected the sample that the author sent him to very careful examination, and found that the outside eutectic areas were actually phosphide of iron, but that following this was an area containing very little phosphorus eutectic, but phosphorus in solid solution. The question that occurred to him was how, if there was phosphide of iron in solid solution, there could be further outside phosphide in the eutectic form. That was rather difficult to explain. One explanation was that, on the oxidation of the outside envelope, the iron oxidised before the phosphide part, and the phosphide gradually contracted inwards into the metal. A very similar kind of thing occurred when copper ores were calcined. Although the copper might be evenly distributed throughout the mass, eventually the copper was found mainly in the centre of the nodule. Some action of that kind might have taken place in the author's case. At any rate, it was satisfactory to know that it was phosphide of iron and not carbide. With regard to the question of the penetration of gases into iron, oxidising gases did penetrate very freely into iron, but the gases that passed the outer surface were incapable of oxidising the iron. They would attack the carbon and form a mixture containing carbonic acid and carbon monoxide. They were continually passing in and out of the iron, but they did not form oxide of iron in the interior. Therefore it was quite to be expected that if one had an envelope free from graphite flakes or passages through which free oxygen could pass, it would be found that there was no oxidation inside the mass itself, and consequently that growth by oxidation of the iron would not occur.

Mr. J. E. Hurst said he ought to have stated in his Paper that he did not put it forward as a universal method for the prevention of growth; he simply put it forward as a method to be used in certain cases with a certain amount of judicious care, and in the hope that it would prove to be of considerable value. In answer to Dr. Hatfield, he would endeavour, in his written reply, to give details of the length of time the various samples had been in actual use. In reply to Mr. Young, the depth of case in the actual sample was 1-16th of an inch on either side of the sample, and 1-16th of an inch core. In reply to Dr. Stead's remarks, he would endeavour to give full details in his written reply.

Whitley Committee's Final Report.

The Whitley Committee appointed by the Prime Minister in October, 1916, to frame suggestions for securing permanent improvement in the relations between employers and workpeople have now published their final report. It is signed by all the sixteen members of the Committee except Mr. Smillie, who could not attend any of the meetings at which the report was considered. The document is a review of the four previous reports, and it points out that if the Committee made further inquiries there would be overlapping either with the work now being done by the Central Departments or with the functions of the Industrial Councils. The bulk of the report appears below :—

Taking our first and second Reports together, they constitute a scheme designed to cover all the chief industries of the country and to equip each of them with a representative joint body capable of dealing with matters affecting the welfare of the industry in which employers and employed are concerned. We have considered it no less important that in each factory or workshop, where the circumstances of the industry permit, and when the conditions which we have stated are fulfilled, there should be a Works Committee, representative of the management and the men and women employed, meeting regularly to consider questions peculiar to the individual factory. This question was the subject of our third Report.

We wish to reaffirm our conviction, expressed in the first Report, of the urgency of the matter. Further, we believe that when the Joint Councils have gained confidence and experience in dealing with the urgent problems of the moment they will find their sphere of usefulness to be much wider than they themselves imagined at their first inception. Similarly, Works Committees, beginning perhaps with limited functions, will, we anticipate, without in any way trenching upon matters appropriate to the Industrial Councils, find a continual growth in the list of questions appertaining to the individual factory or workshop that can be dealt with by mutual agreement. We have purposely refrained, throughout our Reports, from making proposals in detail with regard to the constitution of the Councils and Committees or the scope of their functions, because we are convinced that this can only be done satisfactorily by the people engaged in an industry and familiar with all its circumstances.

We note with satisfaction that, following the approval of our first Report by the War Cabinet, the Ministry of Labour has established a special Department to give assistance and information where it may be desired, and to collect and codify the results of the activities and experience of the Councils that have been formed or are coming into existence. In our fourth Report (Cd. 9099) we have made recommendations on conciliation and arbitration. Relying in the main on the methods built up by agreement within the various industries, and looking to an expansion and improvement of these methods resulting from the habit of dealing with common questions in Joint Council, we have limited our new proposals to the establishment of a small Standing Arbitration Council, on the lines of the present Committee on Production, to deal with cases where the parties have failed to come to an agreement under their ordinary procedure and wish to refer their differences to this Council. In this connection we have made suggestions designed to minimise the occurrence of conflicting awards and to secure an interchange of knowledge and experience between persons called upon to act as arbitrators. On the question of the adoption of schemes of profit-sharing and co-partnership we have considered the evidence at present available, and have felt bound to come to the conclusion that it does not justify us in putting forward any general recommendations.

Qualified Approval.

A note attached to the document and signed "J. R. Clynes, M.P., J. A. Hobson, A. Susan Lawrence, J. J. Mallon, and Mona Wilson," says :—"By attaching our signatures to the general reports we desire to render hearty support to the recommendations that Industrial Councils or Trade Boards, according to whichever are more suitable in the circumstances, should be established for the several industries or businesses, and that these bodies, representative of employers and employed, should concern themselves with the establishment of minimum conditions and the furtherance of the common interests of their trades. But while recognising that the more amicable relations thus established between Capital and Labour will afford an atmosphere generally favourable to industrial peace and progress, we desire to express our view that a complete identity of interests between Capital and Labour cannot be thus effected, and that such machinery cannot be expected to furnish a settlement for the more serious conflicts of interest involved in the working of an economic system primarily governed and directed by motives of private profit."

Institute of Metals.

The annual autumn meeting of the Institute of Metals was held last month in the rooms of the Chemical Society, Burlington House, Piccadilly, London, Professor H. C. H. Carpenter (President) in the chair. The President announced that the membership now exceeded 1,000, an increase of nearly 200 having been registered in the past year. A number of papers were read and discussed. The abstracts of two of these are appended herewith. The President was nominated for a second term of office, for the year 1919-1920.

INFLUENCE OF IMPURITIES ON MECHANICAL PROPERTIES OF ADMIRALTY GUN METAL.

By F. Johnson, M.Sc., Member (Birmingham).

(*Abstract.*)

So far as the author of this "Note" has searched, no attempt appears to have been made to make up alloys of Admiralty gun-metal composition from pure metals under standardised conditions, and to ascertain the alteration in mechanical properties which may be brought about by the addition of other metals. This is what the author, under adverse conditions as regards time, material, and assistance, has attempted to do. Before describing the few experiments which it has been possible to carry out, the views and experimental results of other workers are briefly reviewed under the various added elements, with the author's comments thereon.

As already indicated, scarcity of material was one of his difficulties. The ingots made were small and consisted of slabs cast vertically; the test-pieces were all taken from the bottom. The dimensions of the slabs were ¾ in. thick by 4 in. by 3 in. In an iron chill-mould, the rate of cooling of such a thin section would be very rapid. So potent is this factor of rate of cooling that the risk of the influence of the added elements being obscured was great. A second series of alloys was therefore made, each alloy in this series being cast into a pair of exactly similar ingots, one of which provided a test-piece as cast, whilst the other provided a test-piece which was annealed at 700 deg. C. for one hour. The longer time was allowed owing to the drastically chilling conditions, more drastic than in the case of the first series, under which the castings were produced. Every care was taken to pour the metal at about similar temperatures. There was no case of the metal being poured at a dangerously high nor at a dangerously low temperature.

The main features of interest in the results obtained are as follows:—(1) They represent exploratory work, undertaken with the object of ascertaining which element or elements showed promise of utility in the manufacture of gun-metal castings, which exercised a benevolent neutrality, and which were actually detrimental. (2) From the point of view of mechanical properties, the results given by arsenic and antimony are not in accord with the views of previous workers. (3) Nickel had a decidedly beneficial effect in Series I., whilst in Series II. a remarkable increase in ductility was obtained. (4) Lead does not appear seriously to affect the mechanical properties, although it is possible the resistance to shock is lessened. (5) Iron has a beneficial influence on mechanical properties, yield point, tensile stress, and elongation, all these being raised. Its effect on pouring qualities is bad, but much improvement is effected in this respect by the addition of a trace of aluminium. (6) The influence of manganese is bad in every way, the mechanical properties being adversely affected and the pouring qualities also. The surfaces of the castings were bad. (7) The annealing treatment went far towards eliminating ill-effects produced by undesirable additions, notably aluminium and silicon. The general improvement brought about by annealing was remarkable.

Tentatively the following are the chief results which may be expected from using the additions with which the author has experimented.

Impurity (not exceeding 1 per cent.).	Effect on mechanical properties.	Effect on fluidity and surface appearance of chill castings.
Aluminium ...	Hardening and embrittling	Good
Silicon		
Manganese ...	Inappreciable	Bad
Arsenic	„	Good
Antimony	„	Inappreciable
Iron	Strengthening, without loss of ductility	Bad
Nickel	Toughening; increase of ductility	Inappreciable

The test results also show how very important it is, for the purposes of strict comparison, always to cut the test-piece from the same section of the ingot. A noteworthy feature was that the inferiority of a section nearer to the zone of "piping" was not nearly so marked in the ingot containing nickel as in other ingots. Thus nickel seems to confer a double advantage:—(1) It improves the mechanical properties of cast and annealed specimens. (2) The improvement extends to a greater proportion of ingot than in any other case.

USE OF OIL FUEL IN THE FOUNDRY.

By Captain A. E. Plant, A.S.C., Member (on Active Service).

(*Abstract.*)

In the summer of 1915 the first foundry in connection with repair shops was started, owing to the difficulty and delay in obtaining castings in gun-metal and aluminium from local French firms. There was one pit furnace, natural draught, about 20 in. by 20 in., built of fire-brick, and a metal smoke stack 30 ft. high. The foundry consisted of a corrugated iron shed about 25 ft. by 25 ft. The sand was obtained from a pit about 12 miles away, and some old burnt sand carted from a neighbouring foundry was mixed with it to form the floor. One moulder and a foundry labourer were installed. From time to time there were also installed men who were moulders before the war. The only source of supply for metals was the scrap-heap, no new metal being obtainable. All the brass and gun-metal borings that had been accumulated from the machine shop were cleaned by hand magnets, melted in a crucible and run into ingots. The scrap aluminium was broken up and melted in a similar manner.

Finally it was decided to instal a 5-cwt. "Charlier" oil furnace, bought locally. The fuel recommended was a tar oil, which was obtainable at about 30 francs a barrel. There was no burner on this furnace; a ¼-in. gas pipe, led along the top of the air-blast pipe, was bent over at right angles at the end, and was connected to a receiver; this, in turn, being connected to an oil tank mounted on a platform about 12 ft. from the ground. The oil issued in a thin stream at the end of the blast-pipe, and the force of the air-blast (9½ in. water gauge) converted it into a spray. It was regulated in the usual way. When the next demand for tar oil was made, the vendors put up the price considerably. In facing this problem it struck the writer of the present "Note" that it might be possible to utilise a considerable quantity of waste oil and grease that had accumulated from cleaning out engines and gear-boxes of cars and lorries undergoing repairs in the depôt. As the consistency of the waste oil varied very considerably in the various drums, it was decided to obtain a large 600-gallon tank on the premises and to put in all the waste oil to settle. The tank was circular and divided into two compartments, with a drain-cock at the bottom of each for draining off water and dirt. Some small holes were drilled in the dividing plate above the centre line in order that the lighter oil could flow from the first compartment into the second. All the waste oil was poured into the first compartment through a wire-gauze filter of about 1-16-in. mesh. The oil was always drawn off from the top of the second tank, and then passed through a piece of canvas in order to clean it still further from dirt, and it was then emptied into the supply tank about 6 ft. above the furnace level. This oil was found to be quite easy to use. In fact, it gave better results than did the tar oil, and for over two and a half years nothing else but waste oil has been used here.

One of the first troubles encountered was due to the fact that on cold days the oil flowed very sluggishly in the pipes and an irregular flame resulted in the furnace. To overcome this, a small metal receiver was fitted as near to the furnace as was possible. This answered several purposes. Firstly, it could be quickly and easily warmed with a blow-lamp. Secondly, it acted as a final trap to catch the dirt and foreign matter in the oil, and so prevented the end of the oil supply pipe in the furnace from getting blocked. Thirdly, it acted as a reservoir and supplied oil during such short periods as the oil flowed sluggishly in the supply pipe, and thus a steady flame was obtained. The oil consumption with the usual charge of 350 lbs. heavy gun-metal scrap averaged about 9½ gallons, and the time taken (furnace being hot to commence) one hour. The furnace is chiefly used for running down gun-metal borings from the machine shop, and gun-metal and brass scrap; all metal, either new mixings or scrap, being first run into ingots. It is necessary to use plenty of flux to protect the surface of the molten metal from absorbing gases. For melting metal for aluminium castings the furnace is most satisfactory, as the temperature can easily be controlled.

It was next decided to build a vertical furnace to take up to 100-lb. crucibles, and to use the same waste oil as fuel, as the coke obtainable was often small and of poor quality, and there was a great saving of time in melting, and less chance of the metal absorbing injurious gases. The furnace was circular, the casing being of cast iron with a lining of fire-bricks. The blast-pipe had a jet of 1½ in. diameter connected to it, and the jet entered the furnace at such an angle that the issuing flame struck the furnace wall at a tangent, and a whirling motion was produced. The vaporised oil entered the furnace just below the centre of the crucible (not the bottom). The blast-pipe was itself 2¾ in. diameter. Flames and hot waste gases, which exhausted through an opening at the bottom of the furnace, impinged directly on it, so that the blast entered the furnace at a high temperature. The fuel entered the blast-pipe through a ¾-in. steel pipe, just above the place where the hot exhaust gases struck it. Directly in front of the heated portion of the blast-pipe was a cast-iron baffle plate, which deflected the flow of exhaust gases upwards and gave the blast-pipe in front of it the full benefit of all the waste heat. The fuel oil was contained in a 15-gallon tank fitted with a hand air-pump and a pressure gauge. About 5 lbs. of pressure was kept up. In between the fuel tank and the entrance of the oil to the blast-pipe a brass receiver was fitted in order to fulfil exactly the same purposes as the receiver used with the "Charlier" furnace. Between the receiver and the fuel lead pipe to the furnace a small regulating cock was fitted. An electric motor driving a fan at 3,000 r.p.m. provided an air supply at a pressure of 9 in. water gauge. A fire-brick cover on the top of the furnace had a small aperture for charging and inspection.

The melting times varied somewhat, owing to the variation in the temperature and quality of the fuel oil, and consequently the consumption was not constant. An average time to melt 80-lb. gun-metal ingots was 40 minutes, after the furnace had been heated up. When melting aluminium ingot an 80-lb. crucible took about 15 minutes, the furnace being initially hot. Castings in iron, gun-metal, phosphor-bronze, brass, and aluminium are produced in the same building, a portion of the floor being reserved for bronze and brass, as it is found that aluminium and iron castings can be successfully made on the same floor. Over a ton a month of new white metal is made for lining and making die-castings. The monthly average weight of castings produced varies from 5 to 8 tons, and the castings number from 1,600 to 2,500, being very varied in character and weighing from a pound to nearly a ton.

The chief points in favour of using oil fuel in the circumstances under which the author is placed are as follows:—(1) It is only necessary to have the furnace in operation about a quarter or an hour before the crucible and charge are introduced. (2) It often happens that the furnace is not required all day long, and it can be put in and out of operation very quickly. (3) Temperature control is easy and consistent. (4) Saving in transport of solid fuel. (5) Utilising waste oil on the spot. (6) In the case of the "Charlier" furnace, borings and scrap can be melted more easily and economically than could be done in crucibles.

In regard to waste oil, it should be noted that it cannot be used again for lubricating without refining, as it contains quantities of finely divided carbon, mud, and other impurities; therefore its use on the spot in the foundry is a distinctly economical proposition from a financial point of view.

THE partnership heretofore subsisting between Messrs J. Brown and H. N. Brown, engineers, 22, Lincoln Road, Peterborough, under the style of J. & H. Brown, has been dissolved. Mr. H. N. Brown continues.

Phosphorus in Malleable Cast Iron.*

By J. H. Teng, M.Sc. (Bowen Research Scholar in Metallurgy in the University of Birmingham).

The experiments described in this Paper were undertaken at the suggestion of Professor T. Turner, and were conducted at the University of Birmingham. Two series of test-bars were prepared: one by adding phosphoric iron (4 per cent.) to a very pure American washed white iron, and the other by adding the same to irons supplied by Messrs. Shutt & Ganderton, malleable ironfounders, Birmingham. The composition of the American washed white iron was as follows: Combined carbon, 2.93 per cent.; graphitic carbon, 0.15 per cent.; silicon, 0.01 per cent.; sulphur, 0.004 per cent.; phosphorus, 0.01 per cent.; manganese, nil. On analysis the commercial irons yielded the following results:—

	White iron. Per cent.	Grey iron. Per cent.
Combined carbon ...	... 2.670	0.4 0
Graphitic carbon ...	... 0.250	3.120
Silicon	... 0.5c0	2.200
Sulphur	... 0.325	0.036
Phosphorus	... 0.049	0.049
Manganese	... 0.160	0.580

The mixture used in preparing the second series of bars was one part grey and three parts white iron. The hematite iron ore, used as the annealing medium, was ground to pass a ½-in. riddle and then mixed with a certain amount of ore which had been used as a packing material, the proportions of fresh and used ores being dependent on the cross-sectional area of the test-bars.

Tensile, transverse, and bending tests were performed. The bars for tensile tests were circular in section; they were 9 in. long, 1¼ in. at each end had a diameter of 1 in., and the 6 remaining inches at the middle had a diameter of ¾ in. The bars for transverse tests were 10 in. long by 1 in. square. The bars for bending tests were 9 in. long by ½ in. square. In the preparation of these bars it was noticed that, on remelting, the American washed iron lost an average carbon content of 0.24 per cent. and gained an average sulphur content of 0.0027 per cent.

Annealing Process.—The hematite iron ore used for the annealing mixture consisted of one part of fresh ore to from two to four parts of used ore. A mixture of coke and coal was employed to make the gas. The temperature of the annealing oven was slowly raised to 850 deg. C., which temperature was kept up for four days; then it was raised to 900 deg. C., and remained so for one day. The oven was then gradually cooled down to atmospheric temperature and the bars withdrawn.

Tensile Tests.—These showed that the maximum stress, elongation, and reduction of area are gradually lowered with increasing phosphorus, while the yield point is gradually raised. The most marked effects were observed in bars having about 0.25 per cent. phosphorus, which showed a distinct drop in the elongation and reduction. The bars belonging to the "pure iron series" showed a higher yield point but a lower maximum stress, a lower elongation, and a smaller reduction of area than those belonging to the "common iron series." This difference in the mechanical properties between the two series of bars may be attributed to the influence of silicon, sulphur, and manganese which, up to a certain limit, tend to improve the material, quite apart from the fact that these elements have important effects on the annealing process.

Transverse Tests.—Both the transverse strength and the deflection are steadily lowered with increasing phosphorus. In the "pure iron series," the most marked effects were noticed in a bar with about 0.25 per cent. phosphorus, which showed a considerable drop in the deflection; while in the "common iron series" no serious drop was observed in the deflection until a bar with about 0.3 per cent. phosphorus was reached.

Bending Tests.—The bending angle was progressively decreased with increasing phosphorus.

Hardness Tests.—The Brinell hardness number varied from 173 (0.010 phosphorus) to 308 (0.508 phosphorus) in the "pure iron series," and from 150 (0.048 phosphorus) to 273 (0.520 phosphorus) in the "common iron series."

Izod Impact Tests.—Another series of test-bars was prepared for this test. The composition differed from that of the test-bars previously used, so as to confirm, as far as possible, the influence of phosphorus on the annealed specimens. The specimens were packed with iron oxide and annealed under ordinary conditions. The impact tests varied from 8.5 ft.-lbs. (0.06 phosphorus) to 3 ft.-lbs. (0.530 phosphorus).

Appearance of the Fractures of the Bars used for Bending and Transverse Tests.—The fractures of the bending and transverse bars showed peculiar appearances. The fractures of the low-phosphorus content bars were partly dull and apparently amorphous, and partly crystalline, while those of the high-phosphorus content bars were wholly crystalline. Closer observation revealed the fact that the portions of the low-phosphorus content bars which were subjected to compression showed a more or less crystalline appearance, while those portions which were subjected to tension showed a dull appearance. This contrast of the appearance of the fractures of the bars gradually disappeared as the phosphorus content increased. This peculiarity of the fractures led the author to secure a number of specimens from some local works, in order to see, by the appearance of their fractures, whether it was entirely due to the influence of phosphorus or to some other factors as well, with the result that some interesting data were obtained. Three specimens were obtained from three different local works, and they analysed as follows:—

Specimen	C.C.	G.C.	Si.	S.	P.	Mn.
a	1.20	0.75	0.780	0.328	0.048	0.210
b	0.76	1.26	0.541	0.164	0.049	0.288
c	0.62	1.45	0.648	0.247	0.065	0.265

These specimens, which were nearly of the same thickness, were fractured on the vice by bending around a 1-in. round bar, and the fractures examined. Results of bending tests:—Specimen *a*, 45 deg. bending angle; specimen *b*, 80 deg. bending angle; specimen *c*, 150 deg. bending angle. The results of these tests, although not strictly comparable, since the sections of the specimens are not exactly the same, are nevertheless a measure of the malleability of the specimens.

Presence of Sulphide of Iron in Spent Ore.—An attempt was made to trace the origin of the sul-

* Abstract of Paper read before Iron and Steel Institute.

phide of iron which is invariably found in the iron ore that has been used as the annealing medium in the production of malleable castings. The sulphur content of the fresh ores generally used in the Birmingham district does not exceed about 0.02 per cent., whereas the sulphur content of the used ores sometimes reach to 0.3 or 0.4 per cent. Analyses showed that the sulphur content of the fresh ore is 0.016 per cent., while that of the used ore is 0.342 per cent. Subsequent analysis has shown that 0.096 per cent. of the sulphur in the used ore exists as sulphide of iron. Professor Turner concluded that the presence of this sulphide was derived from the action of the reducing gases existing in the furnace at a temperature of about 900 deg. C., and experiments were undertaken in order to see whether this was really so. Pieces of very pure American washed white iron and of common sulphurous white iron were packed with fresh hematite iron ore in two separate fireclay crucibles. The lids having been luted on the crucibles, they were placed in an oxidising annealing muffle furnace, and a temperature of 900 deg. C. was maintained for 72 hours. After the heat treatment the ore was ground down to a fine state of division, and found to be magnetic. On analysis no trace of sulphide of iron could be found, although 1.56 and 1.42 per cent. of metallic iron were obtained from the two samples of ore respectively. These results appear to show that no sulphide of iron is formed in the spent ore when the atmosphere of the annealing furnace is oxidising in character.

Conclusions.

From the results of the foregoing experiments the following conclusions may be drawn:—(1.) The addition of phosphorus does not result in any improvement in the mechanical properties of the malleable casting. (2.) Any addition of phosphorus leads to a deterioration in the mechanical properties, as shown by tenacity, elongation, etc. (3.) The ill effects of phosphorus do not become marked until about 0.2 per cent. of phosphorus has been reached, and this may be considered to be the approximate limit for commercial purposes. (4.) That the presence of a considerable amount of silicon and manganese is of more importance than the absence of sulphur with regard to the success of the annealing operation. (5.) That the origin of the sulphide of iron in the spent oxide is attributable to the presence of sulphur compounds in the reducing atmosphere existing in the annealing furnace at about 900 deg. C.

Adult Education and its Difficulties.

The interim report of the Committee on Adult Education, under the chairmanship of the Master at Balliol, has just been issued as a White Paper. It presents a warm plea for a generous reconstruction of many of the conditions of daily work and life in order to provide the worker, man and woman alike, with fuller opportunities for education. It begins by showing how some men and women fight against all manner of obstacles to satisfy their craving for more knowledge. The evidence obtained shows that the industrial and social conditions of to-day are only too often of such a character as to form insuperable obstacles to adult education.

A number of these industrial obstacles are dealt with in detail; they are: Excessive hours of labour, overtime, the "shift" system, and night work. All these are considered from the point of view of the worker who would also be a student, showing how fatigue and irregularity unfit him for taking advantage of educational opportunities. The view that the community must suffer economic loss as a result of a shortening of working hours is not one to which modern economic science lends any confirmation, and it has indeed received an impressive practical refutation from investigations made by the Ministry of Munitions during the present war. The Committee, therefore, recommend a reduction of the working day. They think that the maximum legal working day should not be more than eight hours, and in certain heavy and exhaustive kinds of work even eight hours appears to them too long. Also that overtime should be more closely regulated and reduced to a minimum, and that there should be special reconsideration for workers whose hours of labour are irregular; further, that regular night work, except where absolutely essential, should be prohibited by law.

The report proceeds to analyse the effects of monotonous work, and to recommend that alternative forms of employment should be encouraged to counteract its depressing mental effect. Pointing to the fatigue not only of the muscles but of the nerves which affects heavy manual workers, the Committee say that excessive labour regularly pursued undoubtedly degrades those who follow it, and recommend that particularly exhausting occupations should be scheduled and more closely regulated by law, and that, wherever possible, mechanical devices should be introduced so that these heavy forms of labour should be altogether superseded.

The need for holidays is strongly urged. In many parts of the country holidays are the exception rather than the rule; in fact, the industrial worker, as a general rule, says the report, does not have "holidays," but periods of "unemployment." That is to say, if he is allowed to take a holiday he loses his wages for the period. The Committee believe that a reasonable holiday without stoppage of pay would have a beneficial effect upon the national life.

It is pointed out that there is undoubtedly a growing feeling of dissatisfaction on the part of workpeople with what they regard as their position of inferiority due to a forced submission to undesirable conditions, and to the subjection of the worker both to the machine and to the will of others who are vested with an authority in which the workers have no share.

The report goes on to discuss the impediments against the development of intellectual interests which are presented by certain social conditions. The first one dealt with is housing. Evidence submitted to the Committee was unanimous in condemning existing housing conditions. A comprehensive scheme of housing reform is of vital importance, especially to women, and upon it will depend in no small measure the extent to which they will be able to play their part in public affairs and to develop intellectual and social interests. The Committee consider it important, therefore, that such a housing reform should be hurried forward, and that women, who are the persons most concerned, should be included in the housing, town planning, public health, and other Committees dealing with this question.

Cooling of Steel in Ingot and other Forms.*

By J. E. Fletcher (Dudley).

After reviewing the work done and results arrived at by previous investigators, the author proceeds to state that it is indisputable that molten steel, no matter how carefully melted, contains a very considerable volume of gas. The reactions which take place during the refining of the charge, under the slag blanket, are largely brought about by the oxidation of the carbon in the pig-iron or scrap. When it is remembered that the volume of carbon monoxide liberated from the time of melting to that of finishing is (at 1,500 deg. C.) roughly 200 times that of the molten charge, and that the rate of gas ejectment is greatest at the bath surface, where, in contact with the reactionary slag and at the point of maximum temperature, the exchanges are most rapid. The tendency, under the high superheat conditions at the slag contact surface, is for the highest carbon-saturated metal to rise and for the comparatively pure iron crystalline grains to sink to the bottom of the bath. It is indisputable, however, that considerable quantities of gas must be retained even in well "killed" steel, and the intimacy of FeO in the reactions involves definite inclusion of this oxide and possibly Fe_2O_3, either in solution or mechanically suspended between the semi-fluid or fluid (?) crystals of iron, or maybe occasionally as definite silicates. In the puddling furnace the variability of slag composition at a given moment during the concluding portions of the "boil" is very noticeable, one portion of the bath being often vigorously boiling whilst another is relatively quiet and the slag is varying in silicate content. The composition of the spongy ball taken from the portion of the bath which first "comes to nature" is often very different from that of the ball made from the final refined product of the same bath, the slags and gassy nature of the two balls being different in physical character and composition.

In the steel open-hearth there must be similar heterogeneity; a difference in gaseous occlusions and oxide inclusions between the surface metal and that nearest the bottom of the bath. The finishing additions must further influence these imprisoned gases and oxides and lead to reactions which continue in the fluid metal within the ladle and the ingots up to the time of freezing. In the shallow baths of hot working furnaces the superheat conditions may easily be such that there is over-refining of the metal where, lying thinly over the banks of the hearth, excessive oxidation takes place, leading to considerable gas evolution when, later, the over-oxidised metal is mixed with the more highly carburised portions in the ladle.

From many observations of the behaviour of such metal in both ingot moulds and sand moulds for steel castings the author is driven to the conclusion that the phenomena of contraction and shrinkage are largely bound up with this question of gas occlusion. It is well known, for instance, that the feeding of a heavy casting is accompanied by vigorous gas escape through the feeding head. A shrinkage cavity is thereby being filled with molten metal, the gaseous contents of the cavity being ejected through the head. Steel or cast iron when highly superheated above their melting points have higher co-efficients of contraction than similar metals melted with but little superheat; the need for cooling down in the ladle before casting overheated steel or cast iron is well known as an antidote to excesive shrinkage or piping troubles.

The repeated annealing of large steel castings will bring about permanent reduction in volume, as instanced in the case of a number of cast steel rings about 16 ft. in diameter which by repeated annealing were reduced from 1½ to 1¾ in. in diameter without appreciable loss in weight or excessive scaling. This would appear to suggest that the gases imprisoned between the intercrystalline boundaries escaped by way of the casting skin and thus allowed a closer crystalline arrangement to persist. A number of long cast steel pump rods cast on the flat and provided with a heavy feeding head at one end only were about 45 ft. long and contracted fully 10 in. The entire contraction was towards the feeder-head end, which remained stationary. When two feeder-heads were employed, one at either end, the contraction was equally divided in the direction of the two feeders, but trouble was experienced by reason of the contractional nip between the two heads, and fracture occurred before the sand could be removed so as to allow free contraction. This and similar experiences with large castings suggests the connection between gas escape during the freezing and feeding of castings and contraction. One may go further and state that it is safe in foundry practice to regard the contraction of a casting as always following the direction of the liberated gas streams as they flow towards the mass centres and feeding heads, the portions last to solidify, and to take the view that contraction may be largely due to the escape and shrinkage of occluded gases during the freezing of the metal. By placing the feeder-heads in such positions as will enable the gases readily to escape, and by keeping the feeders hot and active, thus securing the filling, by molten metal, of the cavities which a moment before were filled with gas, uniform contraction is promoted. Wherever a massive casting section is badly fed and "shrinkage" cavities occur, the rate of contraction of the massive portion is less than that of the thinner and better-fed sections adjacent to it. In reality, then, the less massive sections draw their feeding metal from the neighbouring heavier and more massive portions of the casting.

Cases have been known and observed where cast blocks of mild steel over a ton in weight (thick short slabs of rectangular section cast on the flat) have cooled without any trace of pipe, have proved solid and clean, and when measured have shown less than half the normal coefficient of contraction. In such cases the steel had accidentally, through nozzle stoppage, become nearly frozen in the ladle, and was only just "live" enough to fill the mould without rising into the feeder-head. Apparently, during the prolonged stay in the ladle, occluded gases had escaped, hence the contraction due to gas escape from, and gas cooling within, the cast mass was correspondingly reduced.

Again, the contractional coefficient is greatest in

*Abstract of Paper read at the Autumn Meeting of the Iron and Steel Institute.

the upper portion of a casting. Long castings cast vertically contract most in the upper portions, the pressure head being obviously accountable for the difference. In a casting 10 ft. long the liquid pressure head compressing the imprisoned gas bubbles at the bottom of the casting is about 35 lbs. per sq. in. greater than that at the top. Hence, if it be conceived that all the gases liberated within the metal during freezing become entrapped, the bubbles in the lowest zone occupy less than one-third of the volume occupied by bubbles of similar weight in the upper zone of the casting. Let it be assumed that the difference in volume of the molten steel at, say, 1,600 deg. C. and the cold ingot or casting at 20 deg. is accounted for entirely by the shrinkage in volume of the occluded gases. Taking as the mean linear contraction at 0.2 in. per ft., the ratio between the volume of the liquid steel at 1,600 deg. and the volume of the solid steel at 20 deg. = 1.05, and an ingot 12 in. sq. by 10 ft. long (when cold) would contain 870 cub. in. of gas when molten.

When cooled to 20 deg. the gas volume would be reduced to 138 cub. in. This volume reduction corresponds with a linear contraction of 0.17 in. per ft. In such a casting the effect of liquid pressure head would be to increase the relative imprisoned gas volume gradually from the base to the top of the ingot, the mean reduction per cub. ft. of ingot metal being 73.2 cub. in. The top cubic foot would shrink 97.6 cub. in., whilst the bottom cubic foot would shrink 48.8 cub. in. The corrected contractions (linear) would then be at the top 0.19 in. per ft., and at the bottom 0.14 in. per ft. In an actual casting of similar size 0.22 in. per ft. (mean) has been observed, on the supposition that all the contraction is due to the cooling of occluded gas. Such estimates lead one to conclude that two-thirds of the contraction may be due to such cooling, the remaining third being due to intercrystalline contraction or to the escape of a portion of the occluded gases.

Repeated researches on gas occlusions have shown that all steel and cast iron in the cold state contain a very considerable volume of occluded gas, and it is obvious that as most ingots have a liquid pressure head of at least 15 lbs. per sq. in. experiments even under vacuum conditions cannot exhaust all the occluded gases. There is a further possibility that intercrystalline cohesive forces further compress the imprisoned gases so strongly as to prevent their exhaustion by vacuum methods. This intercrystalline grip may account for much gas expulsion by way of the crystal boundaries during the freezing of the metal. It is not certain that metals homogeneously solid (if such exist) do actually contract during cooling, and it may be safe to hazard the statement that no cast metals are gas-free. This is certainly true of cast iron and steels. Mr. Osmond drew attention to the fact that water from which the occluded vapour had been exhausted, when frozen in a glass tube, did not burst the tube; whereas water containing vapour in suspension, and similarly frozen, caused fracture of the tube. It may be that the presence of occluded gases is related to the phenomenon of dilatation at the recalescence and often at the freezing points of cast alloys and metals.

In foundry practice it is certain that when castings are badly fed and when the insufficient feeding heads are frozen over before the more massive portions of the castings become solid, shrinkage cavities are inevitable, and great and general trouble occurs through the fissuring of the external skin as well as from internal ruptures. It would appear from such considerations that the function of occluded gases in the process of freezing of iron and steel and other metals should not be overlooked. Growing first normally to the cooling surfaces of the mould the primary austenitic crystallites as they freeze eject the gases they contained, when liquid, into the surrounding mother liquor. Forcing their way between the dendritic branches and stems, increasing in volume and the smaller bubbles coalescing during the advance, they strive to reach the centre of the ingot. The smaller skin crystallites growing rapidly close up their ranks in the rear, driving before them the gas streams as the envelope thickens. If the chilling action of the mould is sufficiently rigorous, the gas streams appear to possess enough directive power to control the positions of the axes of crystallisation of the secondary crystals, as in the case of slightly hypo-eutectic cast irons, especially those high in manganese and low in silicon content. The mother liquor into which the primary crystallites grow becomes more and more gas charged, and hence less dense; the growing dendrites droop and break off as they sink in the lighter liquid of the ingot interior, beyond which point the new crystallites forming have their axes in haphazard and confused directions. The gases, however, largely retain their direction, tending to reach the axis of the ingot and rising the while. Such gases as are not entangled and imprisoned between the growing arms of the crystallites, approach the axis and ascend, each layer of metal adding to the volume of the pipe. If the upper portion of the ingot be kept hot, the gases forming the pipe will escape to the air or into the hot-top "feeder" head of the Hadfield type.

The segregatory constituents are driven along with the gas streams. If these streams are hindered and become pocketed anywhere, as in the corner spaces of polygonal ingots, or within the planes which bisect the corner and base pyramid angles, segregates are found, encouraging incipient freezing in the zones, immediately enveloping them, where they are ready to carry out their evil functions in later "ghost" line troubles in the rolled or forged product. It may be further noted that if the gas exit is at the side of a casting instead of (as in an ingot) at the top, the gas streams, according to their strength, give distinct direction to the crystallite axes in the direction of the feeding mass or head, wherever that may be. The author has observed numerous instances where the dendritic axes have been drawn downwards towards feeder-heads whose conduits have been near the bottom of the castings. The normal direction of the axes was of course normal to the mould surface, but here there was distinct deflection downwards (Fig. 1). All such illustrations which occur daily in foundry work point clearly to a much more important function of the escaping and occluded gases than is usually accorded them in the recognised descriptions of the process of metal solidification.

In casting small ingots of white iron, of about eutectic composition, in chill moulds, the crystals freezing normally to the mould surfaces are plates of eutectic, each apparently rhomboidal in form with a central core in which minutely thin plates of iron carbide in an austenitic matrix, roughly parallel to the long, flat sides of the rhomboidal plates of the eutectic, have distinctive flow struc-

Phosphorus in Malleable Cast Iron.*

By J. H. Teng, M.Sc. (Bowen Research Scholar in Metallurgy in the University of Birmingham).

The experiments described in this Paper were undertaken at the suggestion of Professor T. Turner, and were conducted at the University of Birmingham. Two series of test-bars were prepared: one by adding phosphoric iron (4 per cent.) to a very pure American washed white iron, and the other by adding the same to irons supplied by Messrs. Shutt & Ganderton, malleable ironfounders, Birmingham. The composition of the American washed white iron was as follows: Combined carbon, 2.93 per cent.; graphitic carbon, 0.15 per cent.; silicon, 0.01 per cent.; sulphur, 0.004 per cent.; phosphorus, 0.01 per cent.; manganese, nil. On analysis the commercial irons yielded the following results:—

	White iron. Per cent.	Grey iron. Per cent.
Combined carbon ...	2.670	0.40
Graphitic carbon ...	0.250	3.120
Silicon	0.500	2.260
Sulphur	0.325	0.036
Phosphorus	0.049	0.049
Manganese	0.160	0.580

The mixture used in preparing the second series of bars was one part grey and three parts white iron. The hematite iron ore, used as the annealing medium, was ground to pass a ½-in. riddle and then mixed with a certain amount of ore which had been used as a packing material, the proportions of fresh and used ores being dependent on the cross-sectional area of the test-bars.

Tensile, transverse, and bending tests were performed. The bars for tensile tests were circular in section; they were 9 in. long, 1½ in. at each end had a diameter of 1 in., and the 6 remaining inches at the middle had a diameter of ¾ in. The bars for transverse tests were 10 in. long by 1 in. square. The bars for bending tests were 9 in. long by ½ in. square. In the preparation of these bars it was noticed that, on remelting, the American washed iron lost an average carbon content of 0.24 per cent. and gained an average sulphur content of 0.0027 per cent.

Annealing Process.—The hematite iron ore used for the annealing mixture consisted of one part of fresh ore to from two to four parts of used ore. A mixture of coke and coal was employed to make the gas. The temperature of the annealing oven was slowly raised to 850 deg. C., which temperature was kept up for four days; then it was raised to 900 deg. C., and remained so for one day. The oven was then gradually cooled down to atmospheric temperature and the bars withdrawn.

Tensile Tests.—These showed that the maximum stress, elongation, and reduction of area are gradually lowered with increasing phosphorus, while the yield point is gradually raised. The most marked effects were observed in bars having about 0.25 per cent. phosphorus, which showed a distinct drop in the elongation and reduction. The bars belonging to the "pure iron series" showed a higher yield point but a lower maximum stress, a lower elongation, and a smaller reduction of area than those belonging to the "common iron series." This difference in the mechanical properties between the two series of bars may be attributed to the influence of silicon, sulphur, and manganese which, up to a certain limit, tend to improve the material, quite apart from the fact that these elements have important effects on the annealing process.

Transverse Tests.—Both the transverse strength and the deflection are steadily lowered with increasing phosphorus. In the "pure iron series," the most marked effects were noticed in a bar with about 0.25 per cent. phosphorus, which showed a considerable drop in the deflection; while in the "common iron series" no serious drop was observed in the deflection until a bar with about 0.3 per cent. phosphorus was reached.

Bending Tests.—The bending angle was progressively decreased with increasing phosphorus.

Hardness Tests.—The Brinell hardness number varied from 173 (0.010 phosphorus) to 308 (0.508 phosphorus) in the "pure iron series," and from 150 (0.048 phosphorus) to 273 (0.520 phosphorus) in the "common iron series."

Izod Impact Tests.—Another series of test-bars was prepared for this test. The composition differed from that of the test-bars previously used, so as to confirm, as far as possible, the influence of phosphorus on the annealed specimens. The specimens were packed with iron oxide and annealed under ordinary conditions. The impact tests varied from 8.5 ft.-lbs. (0.06 phosphorus) to 3 ft.-lbs. (0.530 phosphorus).

Appearance of the Fractures of the Bars used for Bending and Transverse Tests.—The fractures of the bending and transverse bars showed peculiar appearances. The fractures of the low-phosphorus content bars were partly dull and apparently amorphous, and partly crystalline, while those of the high-phosphorus content bars were wholly crystalline. Closer observation revealed the fact that the portions of the low-phosphorus content bars which were subjected to compression showed a more or less crystalline appearance, while those portions which were subjected to tension showed a dull appearance. This contrast of the appearance of the fractures of the bars gradually disappeared as the phosphorus content increased. This peculiarity of the fractures led the author to secure a number of specimens from some local works, in order to see, by the appearance of their fractures, whether it was entirely due to the influence of phosphorus or to some other factors as well, with the result that some interesting data were obtained. Three specimens were obtained from three different local works, and they analysed as follows:—

Specimen	C.C.	G.C.	Si.	S.	P.	Mn.
a	1.20	0.75	0.780	0.328	0.048	0.210
b	0.76	1.26	0.541	0.164	0.049	0.288
c	0.62	1.45	0.648	0.247	0.065	0.265

These specimens, which were nearly of the same thickness, were fractured on the vice by bending around a 1-in. round bar, and the fractures examined. Results of bending tests:—Specimen *a*, 45 deg. bending angle; specimen *b*, 80 deg. bending angle; specimen *c*, 150 deg. bending angle. The results of these tests, although not strictly comparable, since the sections of the specimens are not exactly the same, are nevertheless a measure of the malleability of the specimens.

Presence of Sulphide of Iron in Spent Ore.—An attempt was made to trace the origin of the sul-

* Abstract of Paper read before Iron and Steel Institute.

phide of iron which is invariably found in the iron ore that has been used as the annealing medium in the production of malleable castings. The sulphur content of the fresh ores generally used in the Birmingham district does not exceed about 0.02 per cent., whereas the sulphur content of the used ores sometimes reach to 0.3 or 0.4 per cent. Analyses showed that the sulphur content of the fresh ore is 0.016 per cent., while that of the used ore is 0.342 per cent. Subsequent analysis has shown that 0.096 per cent. of the sulphur in the used ore exists as sulphide of iron. Professor Turner concluded that the presence of this sulphide was derived from the action of the reducing gases existing in the furnace at a temperature of about 900 deg. C., and experiments were undertaken in order to see whether this was really so. Pieces of very pure American washed white iron and of common sulphurous white iron were packed with fresh hematite iron ore in two separate fireclay crucibles. The lids having been luted on the crucibles, they were placed in an oxidising annealing muffle furnace, and a temperature of 900 deg. C. was maintained for 72 hours. After the heat treatment the ore was ground down to a fine state of division, and found to be magnetic. On analysis no trace of sulphide of iron could be found, although 1.56 and 1.42 per cent. of metallic iron were obtained from the two samples of ore respectively. These results appear to show that no sulphide of iron is formed in the spent ore when the atmosphere of the annealing furnace is oxidising in character.

Conclusions.

From the results of the foregoing experiments the following conclusions may be drawn:—(1.) The addition of phosphorus does not result in any improvement in the mechanical properties of the malleable casting. (2.) Any addition of phosphorus leads to a deterioration in the mechanical properties, as shown by tenacity, elongation, etc. (3.) The ill effects of phosphorus do not become marked until about 0.2 per cent. of phosphorus has been reached, and this may be considered to be the approximate limit for commercial purposes. (4.) That the presence of a considerable amount of silicon and manganese is of more importance than the absence of sulphur with regard to the success of the annealing operation. (5.) That the origin of the sulphide of iron in the spent oxide is attributable to the presence of sulphur compounds in the reducing atmosphere existing in the annealing furnace at about 900 deg. C.

Adult Education and its Difficulties.

The interim report of the Committee on Adult Education, under the chairmanship of the Master at Balliol, has just been issued as a White Paper. It presents a warm plea for a generous reconstruction of many of the conditions of daily work and life in order to provide the worker, man and woman alike, with fuller opportunities for education. It begins by showing how some men and women fight against all manner of obstacles to satisfy their craving for more knowledge. The evidence obtained shows that the industrial and social conditions of to-day are only too often of such a character as to form insuperable obstacles to adult education.

A number of these industrial obstacles are dealt with in detail; they are: Excessive hours of labour, overtime, the "shift" system, and night work. All these are considered from the point of view of the worker who would also be a student, showing how fatigue and irregularity unfit him for taking advantage of educational opportunities. The view that the community must suffer economic loss as a result of a shortening of working hours is not one to which modern economic science lends any confirmation, and it has indeed received an impressive practical refutation from investigations made by the Ministry of Munitions during the present war. The Committee, therefore, recommend a reduction of the working day. They think that the maximum legal working day should not be more than eight hours, and in certain heavy and exhaustive kinds of work even eight hours appears to them too long. Also that overtime should be more closely regulated and reduced to a minimum, and that there should be special reconsideration for workers whose hours of labour are irregular; further, that regular night work, except where absolutely essential, should be prohibited by law.

The report proceeds to analyse the effects of monotonous work, and to recommend that alternative forms of employment should be encouraged to counteract its depressing mental effect. Pointing to the fatigue not only of the muscles but of the nerves which affects heavy manual workers, the Committee say that excessive labour regularly pursued undoubtedly degrades those who follow it, and recommend that particularly exhausting occupations should be scheduled and more closely regulated by law, and that, wherever possible, mechanical devices should be introduced so that these heavy forms of labour should be altogether superseded.

The need for holidays is strongly urged. In many parts of the country holidays are the exception rather than the rule; in fact, the industrial worker, as a general rule, says the report, does not have "holidays," but periods of "unemployment." That is to say, if he is allowed to take a holiday he loses his wages for the period. The Committee believe that a reasonable holiday without stoppage of pay would have a beneficial effect upon the national life.

It is pointed out that there is undoubtedly a growing feeling of dissatisfaction on the part of workpeople with what they regard as their position of inferiority due to a forced submission to undesirable conditions, and to the subjection of the worker both to the machine and to the will of others who are vested with an authority in which the workers have no share.

The report goes on to discuss the impediments against the development of intellectual interests which are presented by certain social conditions. The first one dealt with is housing. Evidence submitted to the Committee was unanimous in condemning existing housing conditions. A comprehensive scheme of housing reform is of vital importance, especially to women, and upon it will depend in no small measure the extent to which they will be able to play their part in public affairs and to develop intellectual and social interests. The Committee consider it important, therefore, that such a housing reform should be hurried forward, and that women, who are the persons most concerned, should be included in the housing, town planning, public health, and other Committees dealing with this question.

Cooling of Steel in Ingot and other Forms.*

By J. E. Fletcher (Dudley).

After reviewing the work done and results arrived at by previous investigators, the author proceeds to state that it is indisputable that molten steel, no matter how carefully melted, contains a very considerable volume of gas. The reactions which take place during the refining of the charge, under the slag blanket, are largely brought about by the oxidation of the carbon in the pig-iron or scrap. When it is remembered that the volume of carbon monoxide liberated from the time of melting to that of finishing is (at 1,500 deg. C.) roughly 200 times that of the molten charge, and that the rate of gas ejectment is greatest at the bath surface, where, in contact with the reactionary slag and at the point of maximum temperature, the exchanges are most rapid. The tendency, under the high superheat conditions at the slag contact surface, is for the highest carbon-saturated metal to rise and for the comparatively pure iron crystalline grains to sink to the bottom of the bath. It is indisputable, however, that considerable quantities of gas must be retained even in well "killed" steel, and the intimacy of FeO in the reactions involves definite inclusion of this oxide and possibly Fe_2O_3, either in solution or mechanically suspended between the semi-fluid or fluid (?) crystals of iron, or maybe occasionally as definite silicates. In the puddling furnace the variability of slag composition at a given moment during the concluding portions of the "boil" is very noticeable, one portion of the bath being often vigorously boiling whilst another is relatively quiet and the slag is varying in silicate content. The composition of the spongy ball taken from the portion of the bath which first "comes to nature" is often very different from that of the ball made from the final refined product of the same bath, the slags and gassy nature of the two balls being different in physical character and composition.

In the steel open-hearth there must be similar heterogeneity; a difference in gaseous occlusions and oxide inclusions between the surface metal and that nearest the bottom of the bath. The finishing additions must further influence these imprisoned gases and oxides and lead to reactions which continue in the fluid metal within the ladle and the ingots up to the time of freezing. In the shallow baths of hot working furnaces the superheat conditions may easily be such that there is over-refining of the metal where, lying thinly over the banks of the hearth, excessive oxidation takes place, leading to considerable gas evolution when, later, the over-oxidised metal is mixed with the more highly carburised portions in the ladle.

From many observations of the behaviour of such metal in both ingot moulds and sand moulds for steel castings the author is driven to the conclusion that the phenomena of contraction and shrinkage are largely bound up with this question of gas occlusion. It is well known, for instance, that the feeding of a heavy casting is accompanied by vigorous gas escape through the feeding head. A shrinkage cavity is thereby being filled with molten metal, the gaseous contents of the cavity being ejected through the head. Steel or cast iron when highly superheated above their melting points have higher co-efficients of contraction than similar metals melted with but little superheat; the need for cooling down in the ladle before casting overheated steel or cast iron is well known as an antidote to excessive shrinkage or piping troubles.

The repeated annealing of large steel castings will bring about permanent reduction in volume, as instanced in the case of a number of cast steel rings about 16 ft. in diameter which by repeated annealing were reduced from 1½ to 1¾ in. in diameter without appreciable loss in weight or excessive scaling. This would appear to suggest that the gases imprisoned between the intercrystalline boundaries escaped by way of the casting skin and thus allowed a closer crystalline arrangement to persist. A number of long cast steel pump rods cast on the flat and provided with a heavy feeding head at one end only were about 45 ft. long and contracted fully 10 in. The entire contraction was towards the feeder-head end, which remained stationary. When two feeder-heads were employed, one at either end, the contraction was equally divided in the direction of the two feeders, but trouble was experienced by reason of the contractional nip between the two heads, and fracture occurred before the sand could be removed so as to allow free contraction. This and similar experiences with large castings suggests the connection between gas escape during the freezing and feeding of castings and contraction. One may go further and state that it is safe in foundry practice to regard the contraction of a casting as always following the direction of the liberated gas streams as they flow towards the mass centres and feeding heads, the portions last to solidify, and to take the view that contraction may be largely due to the escape and shrinkage of occluded gases during the freezing of the metal. By placing the feeder-heads in such positions as will enable the gases readily to escape, and by keeping the feeders hot and active, thus securing the filling, by molten metal, of the cavities which a moment before were filled with gas, uniform contraction is promoted. Wherever a massive casting section is badly fed and "shrinkage" cavities occur, the rate of contraction of the massive portion is less than that of the thinner and better-fed sections adjacent to it. In reality, then, the less massive sections draw their feeding metal from the neighbouring heavier and more massive portions of the casting.

Cases have been known and observed where cast blocks of mild steel over a ton in weight (thick short slabs of rectangular section cast on the flat) have cooled without any trace of pipe, have proved solid and clean, and when measured have shown less than half the normal coefficient of contraction. In such cases the steel had accidentally, through nozzle stoppage, become nearly frozen in the ladle, and was only just "live" enough to fill the mould without rising into the feeder-head. Apparently, during the prolonged stay in the ladle, occluded gases had escaped, hence the contraction due to gas escape from, and gas cooling within, the cast mass was correspondingly reduced.

Again, the contractional coefficient is greatest in

*Abstract of Paper read at the Autumn Meeting of the Iron and Steel Institute.

the upper portion of a casting. Long castings cast vertically contract most in the upper portions, the pressure head being obviously accountable for the difference. In a casting 10 ft. long the liquid pressure head compressing the imprisoned gas bubbles at the bottom of the casting is about 35 lbs. per sq. in. greater than that at the top. Hence, if it be conceived that all the gases liberated within the metal during freezing become entrapped, the bubbles in the lowest zone occupy less than one-third of the volume occupied by bubbles of similar weight in the upper zone of the casting. Let it be assumed that the difference in volume of the molten steel at, say, 1,600 deg. C. and the cold ingot or casting at 20 deg. is accounted for entirely by the shrinkage in volume of the occluded gases. Taking as the mean linear contraction at 0.2 in. per ft., the ratio between the volume of the liquid steel at 1,600 deg. and the volume of the solid steel at 20 deg. = 1.05, and an ingot 12 in. sq. by 10 ft. long (when cold) would contain 870 cub. in. of gas when molten.

When cooled to 20 deg. the gas volume would be reduced to 138 cub. in. This volume reduction corresponds with a linear contraction of 0.17 in. per ft. In such a casting the effect of liquid pressure head would be to increase the relative imprisoned gas volume gradually from the base to the top of the ingot, the mean reduction per cub. ft. of ingot metal being 73.2 cub. in. The top cubic foot would shrink 97.6 cub. in., whilst the bottom cubic foot would shrink 48.8 cub. in. The corrected contractions (linear) would then be at the top 0.19 in. per ft., and at the bottom 0.14 in. per ft. In an actual casting of similar size 0.22 in. per ft. (mean) has been observed, on the supposition that all the contraction is due to the cooling of occluded gas. Such estimates lead one to conclude that two-thirds of the contraction may be due to such cooling, the remaining third being due to intercrystalline contraction or to the escape of a portion of the occluded gases.

Repeated researches on gas occlusions have shown that all steel and cast iron in the cold state contain a very considerable volume of occluded gas, and it is obvious that as most ingots have a liquid pressure head of at least 15 lbs. per sq. in. experiments even under vacuum conditions cannot exhaust all the occluded gases. There is a further possibility that intercrystalline cohesive forces further compress the imprisoned gases so strongly as to prevent their exhaustion by vacuum methods. This intercrystalline grip may account for much gas expulsion by way of the crystal boundaries during the freezing of the metal. It is not certain that metals homogeneously solid (if such exist) do actually contract during cooling, and it may be safe to hazard the statement that no cast metals are gas-free. This is certainly true of cast iron and steels. Mr. Osmond drew attention to the fact that water from which the occluded vapour had been exhausted, when frozen in a glass tube, did not burst the tube; whereas water containing vapour in suspension, and similarly frozen, caused fracture of the tube. It may be that the presence of occluded gases is related to the phenomenon of dilatation at the recalescence and often at the freezing points of cast alloys and metals.

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tures (Fig. 2). The axial direction of each plate crystal is about normal to the chill surface, and is deflected apparently by gas-flow influence towards the hot mass centre. If there be a cavity or pipe in the ingot, the axes of the plates point in the direction of that cavity, and the core crystals within the main crystals of the eutectic have themselves a flow structure which is always directed

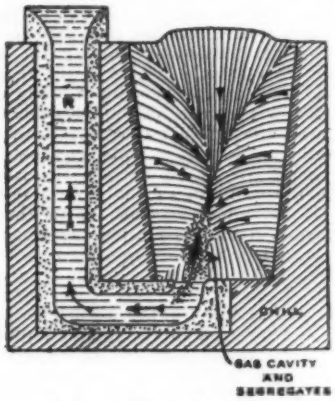


FIG. 1.—WHITE-IRON INGOT.

Top poured into iron mould containing liquid slag. Slag displaced escaped by riser R. Gas escape paths indicated by arrows.

towards the pipe, cavity, or centre of the ingot. This statement should be qualified by saying that the definite orientation of the plate crystals persists only so long as the chilling influence of the mould surface is sufficiently powerful, or, the tem-

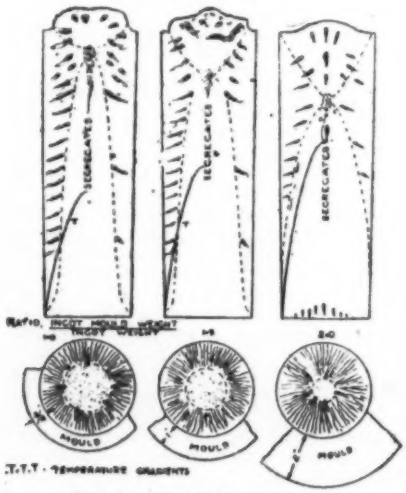


FIG. 2.—FLOW STRUCTURES.

perature gradient of cooling remains sufficiently steep.

Before leaving the subject of gas ejectment from molten masses, mention should be made of interesting phenomena which may at any time be observed during the freezing of iron and steel castings. The upper surface of an open sand-cast plate or that of an ingot cast in a thick mould (without hot top feeder) often clearly shows rings or polygons of gas bubbles concentric with the mould form. The edges next to the mould remain clear of bubbles and shrink downwards towards the mould surface, leaving a rounded surface free from gas bubbles, sometimes extending an inch inwards from the mould. The outer rings of bubbles are of small size; as they approach the ingot or plate centre they increase in size, but are fewer in number, and are spaced further apart. In the top surface of a square ingot the bubbles rise most copiously along

FIG. 3.—SLAG INGOTS CAST IN IRON MOULDS.

S = Secondary Crystals.
P = Primary Crystals.

Note annealing effect on Primary Crystal Zone at A, Secondary Crystals forming.

the diagonals, and in certain alloy steels and white iron the upper surface shrinks, leaving a hollow of inverted pyramid form along the corners of which when cold the bubble paths can readily be traced. The pickling in acid of a seemingly solid open sand-cast plate yields a porous surface, and very clearly defines the progress of freezing in the neighbourhood of the corners and edges. By spraying cold water on local spots at the surface of a molten open sand-plate the gas bubbles may be suppressed in the chilled areas, but around them in the adjacent molten metal others burst out more vigorously. Anyone who has had experience in the pickling of steel castings preparatory to galvanising will have noticed the porosity of the envelope, especially near the roots of re-entrant angles as where ribs join plane surfaces and in the

FIG. 4.—FLUE CINDER INGOT CAST SLOWLY.

neighbourhood of massive sections which have not been perfectly fed.

The influence of occluded gases can be well studied by means of ingots and other forms cast from flue cinder from puddling or pile reheating furnaces. The rapid freezing of this material plainly indicates the gas function, producing "pipe" phenomena with volcanic effect, the top crust often being raised by the gas pressure within the hidden "pipe." By locally heating the central portion of the crust of a flue cinder ingot the feeding effect is rapidly produced; during the period of feeding gas escapes copiously and ceases when the "pipe" is filled. The primary chill crystals radiating from the mould surface and the secondary crystals of confused orientation are well illustrated in Fig. 3, which shows two ingots of ferrous sili-

cate slag. The effect of casting conical moulds with the small end upwards and *vice versa* on the "pipe" contour is clearly indicated. An ingot of flue cinder run very slowly illustrates the behaviour of steel when slowly teemed into a thick mould, exaggerating the defects brought about by excessively slow teeming. The effect of the atmospheric chilling on the rising surfaces of the liquid and of the freezing action of the mould contact is seen in the shrinking of the successive strata at the ingot surface, just as in the case of the open sand-cast plate already mentioned. Each layer of molten metal overruns a lower one whose edges are already frozen; hence a lap occurs, the two surfaces being only partially welded together. In some cases the overhanging "lap" can be prized or chipped off. Fig. 4 is a sketch of a typical ingot section from a flue cinder wagon which was filled gradually by dribbling ferrous silicate slag.

Further, the liberated gases cannot get away to the top of the ingot and become entrapped in lenticular horizontal cavities, which are more or less lined with primary crystals. The nearer the top of the ingot the larger the cavities; the lower ones being smoother at their surfaces and rounded in form, clearly indicate gas pressure.

Cast iron, especially if low in total carbon, when cast into typical ingot form, yields very useful results in the study of mass influence on the rate of freezing and cooling. Such iron ingots were cast into iron moulds of various thickness, and temperature curves of the heating up of the moulds at definite points within the mould mass were taken and plotted in a diagram. The mould was 13 in. outside diameter with a bore of 5½ in. and rested on a bed of sand, the bottom of the ingot being thus in contact with sand. The temperatures were taken at points ¼ in., 2¼ in., and 2⅞ in. from the outside of the mould. The temperature curves showed a slow heating up of the mould during the first minute after casting. In other repetitions of the experiment with sand moulds as well as with metal moulds this lag was clearly indicated. It apparently coincided with the period of freezing of the ingot, the internal heat evolved at the moment of solidification being absorbed in intercrystalline reactions which appeared to affect the rate of heat flow outwards to the mould. The phenomenon is obviously associated with those observed by Professor Turner in his experiments on the volumetric changes in cast iron during cooling from the molten state. The three curves indicated different velocities of temperature rise throughout the mass of the mould, as might be expected. The curves did not reach a common equilibrium point, due to the cooling action of the air on the mould exterior. It was noticeable that it was only when the ingot and mould cooled down together slowly that there was reached, after 1¼ hours, an approximately common temperature. The curves showed a slackening of speed in heating after about three minutes, the flat portions between 3 to 4 min. and 8 to 12 min. being very marked. The same slackening and flattening of the heating curves has been noted in the case of ingots cast in thinner moulds but at a higher temperature. This phenomenon appears to be related to the recalescence range in the cooling of the ingot.

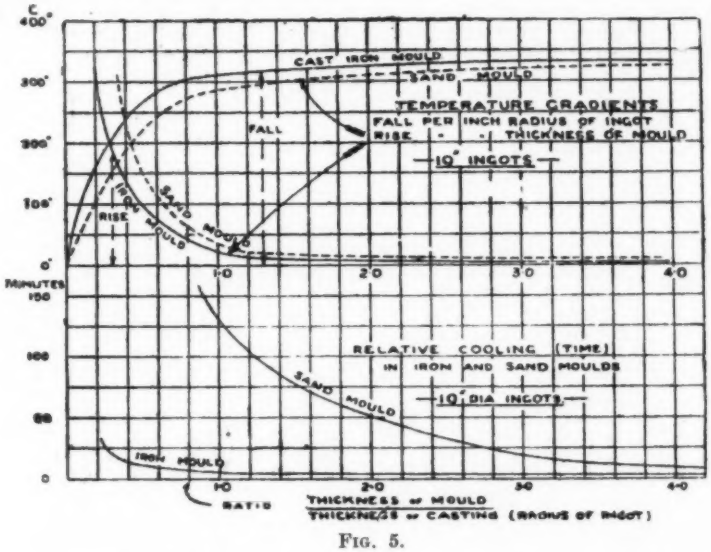


FIG. 5.

The relationship between the heating up of the mould and the corresponding cooling down of the ingot can be expressed by the following equation:—

$$\text{Heat lost by Ingot.} \quad M_1 \times S_1 \times (T_1 - T_2) = M_2 \times S_2 \times (T_4 - T_3) \quad \text{Heat gained by Mould.}$$

Where M_1, M_2 = Weight of ingot and mould respectively.
S_1, S_2 = Specific heat of ingot and mould respectively
T_1 = Initial mean temperature of ingot.
T_2 = " " mould.
T_3 = Final mean temperature of ingot.
T_4 = " " mould.

By assuming $S_1 = 0.17$ and $S_2 = 0.14$ (Harker's experiments on specific heat), and by assuming T_2 and T_4 equal it is possible to arrive at the ratio:

$$R = \frac{T_1 - T_2}{T_4 - T_3}$$

It will be found that the rise in temperature of the mould up to the flattening of the curves, if

multiplied by the ratio R, will indicate the temperatures in the ingot corresponding with the slackening phenomena. It corresponds with the recalescence range at about 700 deg. C., and would appear to suggest that the heat evolved during recalescence is absorbed internally, and that, further, the external heat flow is retarded during this period. This phenomenon is noticeable during the heating of steel, and is clearly shown in Mr. E. F. Law's recent Paper on the "Effect of Mass on Heat Treatment." The inflow of heat during heating through the Ac1 range is retarded, such retardation being very marked in the central portion of the forging under treatment.

The rate of cooling was always inversely as the diameter, side of square, or face of polygon, and decreased as the ratio of length to diameter or side increased.

From records taken of the rise in temperature of sand and iron moulds the diagram in Fig. 5 has been prepared. The interesting point brought out is that when the weight of the mould exceeds twice that of the ingot the increase of mould-metal thickness does not further speed up the cooling action materially. The effect of increasing the mould thickness in chilling or cooling the

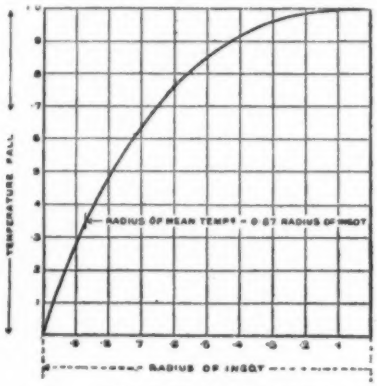


FIG. 6.—TEMPERATURE GRADIENTS.

ingot or casting is greatest when the ratio of mould thickness to that of the casting or radius of ingot is below 0.25 in metal and below 1.0 in said moulds. In the latter the rate of cooling diminishes progressively as the thickness of the sand mould exceeds twice that of the steel castings. When the mould thickness (sand) exceeds eight times that of the casting any further chilling action is negligible. The practical use of the above investigation is obvious. It can be proved therefrom that in a cast-iron chill half the ingot weight cast therein cannot stand, the temperature of the inner surface reaching the melting point of cast iron.

The foregoing estimations and deductions only refer to mean temperature gradients, hence it is further necessary to investigate more closely the change in the gradient which gradually occurs between the outer surface and the axis of the ingot mass. Taking first the case of the cooling of a spherical mass within a mould. The gradients are computed by conceiving the sphere to be built up of concentric hollow spheres surrounding a centre sphere, each hollow and centre sphere being of equal mass. The surface of the outer sphere is cooled by contact with the mould, and there is a fall in temperature throughout the mass of the outer hollow sphere. The succeeding inner sphere is cooled by contact with the outer sphere, and so on until the central nucleus is reached. The ratio of cooling surface to volume decreases in each of the hollow spheres as the centre is approached, the fall in temperature in each of the zones being directly proportional to the ratio C/M, where C is the cooling surface and M is the mass or weight of the concentric hollow sphere or spherical nucleus. The fall in temperature in each zone divided by the thickness of the zone is the temperature gradient, which is the index to the speed of cooling. By assuming zones infinitely thin the curve of temperature gradients can be mathematically determined, which form a continuously falling curve from the outer surface to the core of the sphere, as plotted in Fig. 6. A similar study of the progressive cooling of a mass within a hollow cube mould shows that the curve of temperature gradients from the centre of each face inwards is the same as that of the inscribed sphere. The corners and edges of such a cube cool more rapidly than the faces, and this can be shown by a consideration of the elementary Fig. 7 (*a*), where a

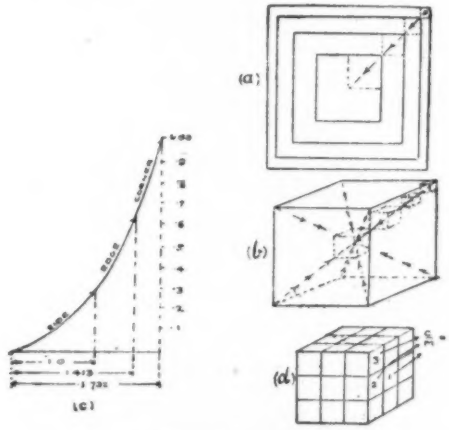


FIG. 7.—TEMPERATURE GRADIENTS.

cube is divided into 27 smaller cubes. The centre of each face has the cooling ratio of 1, the 8 corner cubes have the cooling ratio 3, and the 12 edge cubes the ratio 2, whilst the central "kernel" cube has R=0. The mean ratio of the 27 cubes is therefore 2. Again, assume the elementary cube to be built up of a number of concentric hollow cubes surrounding a centre cube, each zone being of the same volume. The outer cooling surface of each hollow cube acts upon the mass within it, the fall of temperature being proportional to the ratio C/M, where C = outer cooling surface of the hollow sphere and M = mass of same, as in the case of the sphere already considered. The temperature fall in each hollow cube (normal to the faces) divided by the thickness of the wall is the temperature gradient and the index to the rate of cooling. The successive temperature gradients from the outside to the centre of the cube form a curve which is readily determinate. It is the same curve as that of the sphere of diameter equal to the

side of the cube (Fig. 6). Further, following the same method of determination, the curve of temperature gradients can be fixed for the succession of cubes running diagonally from the edges of the outer hollow cube to the "kernel" cube (see Fig. 7 (*a*)), each of which has the cooling ratio R = 2. This curve is found to be the continuation of the one first determined, viz., that running from the centre of the faces to the centre of the main cube. The continuation portion of the curve increases in steepness as it approaches the outer cooling edge. Again and similarly the curve of gradients can be found for the succession of cubes running diagonally from corner to corner of the main cube, each of which has the cooling ratio R=3 (see Fig. 7 (*b*)). The curve thus found is the continuation of the curve passing from the nucleus to the edges, the gradient becoming steeper as the corner is approached. Fig. 7 (*c*) shows the combination of the three curves, and is practically useful in illustrating the fact that the progressive freezing and cooling of a square ingot at its base is that of a hemisphere within a semi-cube, the corners and edges of which are cooling at a more rapid rate than the faces. This, of course, is roughly understood in practice, but it has not previously been shown that the rates of cooling follow readily definable and continuous curves.

The lines of most rapid freezing and cooling therefore follow the paths of steepest temperature gradients, and these are the bisecting planes of the mould sides and those bisecting the base angles and constituting the base cone or pyramid first referred to by the author in a paper on the "Influence of Gases in Iron and Steel," read before the Staffordshire Institute in 1907, and since referred to by Messrs. H. and W. Brearley in their paper on "Steel Ingots" in 1916. The relative rate of freezing of long ingots is slower than that of short ones, the influence of the base chilling being greater the shorter the ingot. Hence the cooling of the central and upper portions of a long ingot is much slower than at the base, especially in bottom-run ingots, where the steel becomes gradually cooler as it rises in the mould. The temperature head then decreases continuously, and simultaneously the temperature gradients slow down as the upper portions of the mould are approached.

From actual determinations of the temperature gradients in cast-iron blocks, cast in iron moulds, arrived at from temperature rise readings at time intervals, it has been possible to deduce certain valuable basis figures, useful in the plotting of the probable isotherms within cooling masses, such as ingots. Thus the heat absorbed by the cooling surface of a 5.5-in. ingot mould 13 in. outside diameter directly following the casting of the iron ingot was as under:—

(1) Time of casting and 4 minutes after. Temperature rise per minute, 33°C.
(2) 4 to 12 minutes after casting. Temperature rise per minute, 17°C.
(3) 12 to 20 minutes after casting. Temperature rise per minute, 3°C.

The heat calories absorbed per sq. in. of mould cooling surface in contact with the ingot was in periods (1), (2) and (3), 3.50 cals., 1.75 cal., and 0.30 cal. per min. respectively. The temperature head in the period (1) was 1,180 to 1,050 deg. C., in (2) 1,050 to 915 deg. C., in (3) 915 to 900 deg. C. By equating the heat gained by the mould with that lost by the ingot it is easy to arrive at the fall in the mean temperature of the ingot in each of the three periods following casting. The temperature gradients obtained by measurement at fixed points in the mould and plotted from the heating curves enable the corresponding cooling gradients in the ingot mass to be predicted.

From such methods and from observations made on the heating of ingot moulds of known weight, it has been possible to follow the case of a 12-in. sq. ingot 4 ft. long cast in a mould twice its weight, and to deduce from calculation and experiment the approximate isotherms within ingots cast in one minute and in four minutes respectively. The influence of casting wide or narrow end down, of top and bottom casting, and of closed top moulds has been examined, and the results of the calculations are illustrated. The effect of the chilling action of the mould during the teeming of the ingot has been calculated by plotting the values of the ratio R=C/M as the liquid rises inch by inch in the mould. From this it was possible to plot a similar curve indicating the mean fall in temperature at all levels from the bottom to the top of the ingot. In Fig. 8 two curves are shown, one giving the case of the ingot cast in one minute, the other cast in four minutes. The mean temperature fall in each case is plotted to show the state of things one minute after the ingot has been cast. The isotherms corresponding to the temperature fall curves are shown. The dotted line gives the modification in the temperature fall in the case of an ingot cast with narrow end down and with open top.

Suppose the casting temperature to be 1,500 deg. and the freezing temperature to be 1,480 deg. C. It is seen that the ingot cast in one minute is liquid in the upper half of its length, whereas that cast in four minutes has a solid envelope throughout its length of a thickness of about 3 in. at the centre of its length one minute after casting has been completed. The diagrams are only approximately correct, but the values of C/M taken in conjunction with observed values of the temperature gradients and of the heat absorbed per min. per sq. in. of mould contact surface during defined intervals after casting have been carefully checked from numerous examples, and it is believed that the main features of the diagrams are correct. In the absence of correct values for the latent heat of fusion of steel the influence of such has had to be ignored. The result of such a correction would be to slow down the rate of cooling somewhat, the thickness of the envelopes would be slightly less per unit of cooling time than those shown. It is certain that the results obtained are comparative. With larger ingots the rate of cooling can be foreseen, it being recognised that this is inversely as the diameter, and the mean thickness of the frozen envelope per unit of time will be proportional to the rate of teeming in the case of ingots whose moulds are of weight bearing a constant ratio to that of the ingot. The influence of slow teeming in moulds wide end uppermost is also indicated in Fig. 8. Here the envelope thickens rapidly in the lower portion and is thus strong enough to resist the internal bursting pressure which in rapidly teemed ingots in top cast moulds with wide end bottom is sufficient to burst the skin and to cause the surface defects pointed out by Mr. Kilby in his recent Paper on ingot defects. Time teeming and the efficacy of slow pouring in comparatively heavy moulds has long been practised abroad and in some works here, but the

recognised need for it is only now being generally understood.

The isotherms shown in Fig. 8 and the remarks made on edge, base, and corner freezing lead to the conclusion that Messrs. Brearley's concentric freezing diagrams are not quite correct, the true form of the freezing envelopes being more approximately that of M. Harmet, especially in the case of smaller ingots cast in heavy moulds and slowly teemed, with hot tops. The effect of rapid cooling of the base, corners, and edges, together with the augmenting influence thereon of the liquid pressure head, is to round off the corners of the progressively freezing envelopes, this result being most marked in the case of small ingots cast in heavy chill moulds.

The base freezing is perhaps best followed in the study of the behaviour of an open sand plate whilst cooling from the liquid state. Such a square plate freezes first at the corners where there is

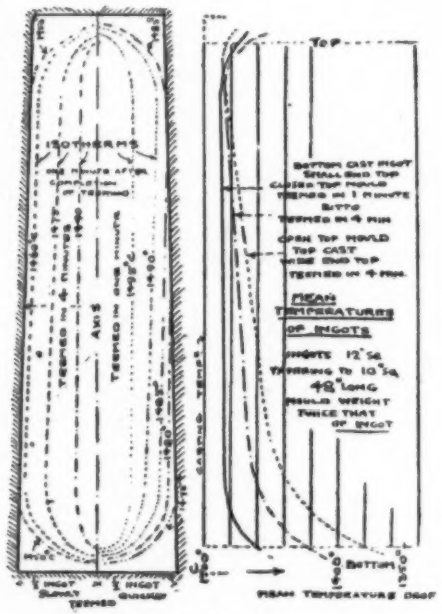


FIG. 8.

considerable shrinkage. The rate of freezing at the corners, edges, and flat surfaces of a square plate is in the proportion of 3, 2, and 1 respectively. The pressure of the superincumbent liquid steel on the base of an ingot, or rather on the frozen plate first layer to form in the mould, has a bursting or tearing effect on the skin, cracks following the line of weakness, where the thickness of the frozen skin is insufficient to resist the liquid pressure.

The steep temperature gradients occurring in metal and other masses during drastic heating and cooling affect a wide area of practice. For example, the kilning of sharp-edged fire-bricks produces weakening effects at the edges and corners, rendering them brittle and liable to spall and fracture. The author has proposed the rounding of the edges and corners of arch bricks at the inner surfaces, with a view to securing a better moulded and burnt surface and to obviate the common spalling trouble. The arch thrust is thrown farther back behind the flame contact surfaces, and considerable saving is effected in the breakages common to handling and during the expansion thrust. The old Swedish method of casting ingots with the small end down and with the base end well rounded is obviously correct in principle, and is a practical and truly scientific mode of overcoming the tensile strains inseparable from square-based, sharp-cornered ingots.

It is obvious that to ensure the best results the top of the mould should be thick enough to yield a thick envelope directly under the hot top, whose function is to keep the axial portions of the ingot top hot and liquid.

In considering the problem of perfect skin surfaces it is necessary to bear in mi fact that the actual crystalline structure bon steels at temperatures in excess of 1, C. is unknown, but it is known that the lline boundaries can be fused at about such ra- ture (Stansfield), and though it is h to suggest that there may be a formation ectic 4.3 per cent. carbon colonies at the bou ries at such temperature, there is much to ctically favour the view. What othe constitu would be likely to fuse at 1,150 d . C.? Th fact remains that above such temperature ste is very weak in an intercohesional or inte stalline sense, as is specially demonstrated whe ttempting to extrude or die draw it at te eratures above 1,100 deg. The same weakness n prevail when an ingot is cooling from the molten to 1,100 deg., and it is clear that any process which tends to keep the metal in contact with the mould continuously and which promotes rapid fre g of the envelope, especially in the regions whic ther- wise liable to skin fracture through g or irregular contraction, is to be welcomed.

The author has made many observa n the rate of freezing of cast iron and ste d has found, as might be expected from wh s already been said, that the temperature gradi curve is an index to the speed of freezing from surface to the axis of the ingot or casting. y ast-iron ingots, cast in moulds of varying thickness, when fractured give an excellent ndex to the rate of freezing as influenced by mass of mould. If the iron is low in carbon (hypo-eutectic) the fracture characteristics give clearly defined differences of structure, due to the rate of cooling from the molten, and these, when further examined microscopically, are most instructive.

Many test ingots, made for the purpose of testing the depth of chill for rolls and other chill castings, have been carefully studied, and these also have yielded interesting information on the subject of crystalline structure as related to the rate of cooling as influenced by mass of mould and ingot and of temperature of casting. Generally, it is very evident that the steepness of the outer skin temperature gradient is the index to the chill thickness, and also that of the carbon retained by chilling in the combined state. The steeper the skin zone temperature gradient, the greater is the volume of the carbide within that skin zone. This is but another illustration of Dr. Stead's statement that temperature gradients are a measure of the hardening effect when quenching steels; that when a billet and a thin wire of the same material are quenched in water from above the Ac1 point, the wire may be glass hard, whilst

the billet is still soft. The rapidity of freezing as influencing the chill envelope in low-silicon cast iron is shown in Fig. 9, where (*a*) is the case of the metal poured through water into a very thin water-cooled mould, (*b*) that of a thin water-cooled mould, (*c*) that of a thick metal mould and (*d*) that of a warm sand mould. The four cases present a series of diminishing rates of freezing and cooling.

The suppression of dilatation by rapid cooling has long been known to investigators of permanent mould processes in iron foundries. The troubles which were feared during the freezing range when dilatation was expected did not occur, the sudden chilling having suppressed the heat evolution and dilatation.

The [illegible]d of analysis of the action of cooling,

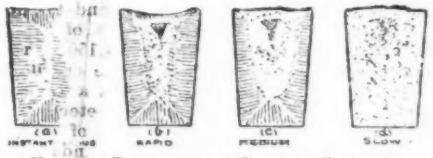


FIG. 9.—INFLUENCE OF RATE OF COOLING.

relating [illegible]mperatur[illegible]head with the temperature gradients [illegible]he ratio of ingot to mould mass, and the infl[illegible]of these with the time factor on the ingot st[illegible]ure zone by zone from the outside to the axis [illegible]apable of yielding most valuable data of a high[illegible]practical nature. The author has only attempted to outline the steps whereby more systematic research would enable further progress to be made in our knowledge of the influence of mass on slowly and quickly cooled or heated cast iron a[illegible]l.

The[illegible] portion of the Paper has been lying aside [illegible]s years or more, but in view of the increa[illegible]terest arising of late in the subject-matter [illegible]ots and of cooling phenomena, it was thought th[illegible]the details of the author's work might sup[illegible]ent that of other investigators.

Carbon Electr[illegible]es for Furnaces.

By J. A. HOLDEN.

The rapid growth of electric furnaces for metallurgical work has created a large demand for carbon electrodes. During the early months of last year especially, this demand was so much in excess of the supply that many furnaces could not be worked. Until recently we were in this country entirely dependent upon supplies chiefly from America and Sweden, but British enterprise has in this instance also risen to the occasion, with the result that amorphous carbon electrodes are now manufactured in large quantities in this country, and the home-made article is superior to many of the imported ones, nay, within a small measure it is equal to the best American amorphous carbon electrodes.

Graphite electrodes are invariably used in furnaces of large capacity, and to some extent also in small furnaces. Compared with those of amorphous carbon their electrical conductivity is very much higher, amounting to about four times as much. The writer has used Acheson graphite electrodes of 5½ in. in diameter to carry a current of 4,500 amps., and although the joint became visibly hot, no serious inconvenience was experienced. The use of graphite renders it possible to adopt a light construction for the holders, together with a corresponding light design for the framework of the hoisting gear. As graphite can be easily machined it is possible to use accurately cut screw-joints and avoid an accumulation of stub ends. Although graphite has many advantages, several points can be urged in favour of amorphous carbon. Graphite electrodes have very small tensile strength, only about one-half of that of amorphous electrodes. In consequence careful manipulation is essential if the number of breakages is to be kept down. Thus in joining, it is necessary to have the two electrodes in perfect alignment, and not to screw them very tightly together. With a little practice one quickly learns to make successful joints, and it is not unusual to make a satisfactory job in three or four minutes. The low electrical conductivity of amorphous carbon is a decided advantage, as by reason of their large size the electrodes act as powerful insulators to the furnace roof, the life of which is much longer than when graphite electrodes are used. In the writer's experience the economy in this direction amounts to about 33 per cent. of the roof cost.

In contradistinction to graphite electrodes, a paste is necessary for joining amorphous carbon electrodes as these are difficult to machine. The threads, both in the electrode and on the plug, are made by moulding in a die, and are consequently not so accurate as are cut threads. The jointing paste is used to produce intimate contact, for arcing would result if all interstices were not filled with a good conductor. An excellent material for making the paste is the best quality Ceylon plumbago ground extremely fine, and mixed with hot anhydrous tar (ordinary gasworks tar is useless) to the consistency of treacle. A suitable jointing paste is marketed by one of the English electrode makers under the name of "Jungo." As the life of an electrode is to a large extent determined by the soundness of the joint, careful attention to this is amply repaid by the results obtained. A preliminary trial is made with several screw-plugs, and one which grips the threads is chosen. The paste is next heated to about 90 deg. C. and smeared over the lower half of the plug, which is then screwed home. Before the new electrode is attached, the projecting half of the plug is also coated lightly with the hot paste. In order to prevent slipping in the holder, the electrodes are made with a slight taper, and to secure a correct joint the diameter has to be measured beforehand with a pair of calipers.

Damp and wet are a prolific source of cracked electrodes, and if the top of an annealing or drying stove can be secured for storage it should be utilised. The electrode consumption has, of course, an important bearing on the cost of production. Some electrodes burn very thin, tapering down to a fine point; they are then said to "point" badly. Such electrodes prove troublesome because they invariably break off, and the delay in removing the fractured pieces causes considerable loss.

IN connection with the shipbuilding enterprise of Vickers, Limited, on the La Plata, it is interesting to note that a concession has been obtained by that firm from the Chamber of Deputies, Buenos Ayres. At Santiago, Chile, a similar development is expected shortly.

Steels for Gears and their Treatment.*

By George A. Richardson.

Classification of Gears.—The question of the grade of material best suited for a given gear or system of gearing comes down to several basic considerations. We may roughly divide all gears into two classes :—(1) Gears which are primarily used merely for the purpose of changing speeds. (2) Gears which are primarily for the purpose of conveying power and must withstand severe service conditions. In one case the cheapest material consistent with convenience is the best; in the other the best material is the cheapest. Assuming that the gears are to be used to convey power, it becomes necessary to consider :—(1) Whether resistance to wear is the most important requirement; or (2) whether resistance to shock of sudden and excessive loads is of importance. When resistance to wear is the most important consideration the general opinion is that case-hardened material will prove more satisfactory than oil-hardened, although there is a considerable amount of evidence to the contrary. Case-hardened material, however, has too brittle a surface and lacks the strength and toughness necessary to withstand the impact of shocks or heavy and excessive loads. Hence an oil-hardened gear will give better service under these conditions.

Gears of Cast Steel.—In many cases cast iron is a better material for gears than cast steel, these depending on whether or not the desired strength can be obtained without taking into consideration the weight. Cast-iron gears are easier to mould, come out cleaner and require less machining than cast-steel gears. Almost all heavy gears, however, for high, severe service are made of cast steel of either the straight carbon or alloy types. Small-sized steel gears may be cast within certain limitations (say, gears weighing 50 lbs. and having a diameter of about 12 in.). For quantity production, however, drop forgings are preferable from every standpoint. They are cheaper to make, more uniform and stand up better in service. An ordinary grade of straight carbon steel is used in this case as a rule. Alloy steel could be used, but it is more difficult to cast and, therefore, not favoured in the small size work.

Gears of Large Size.—For especially severe service large size gears have been manufactured with great success by using a nickel-chrome composition and air-hardening. Such gears outwear three ordinary cast-steel gears. As to the comparative life of cast-steel gears and cast-iron gears, it has been found that the large, treated alloy gears will double or triple the wear of treated cast-iron gears. Ordinary cast iron will not stand up at all and ordinary cast steel, while it will stand up, will not do as well as the specially-treated cast iron.

Ordinary Machinery Steel Gears.—The great majority of gears are made from ordinary straight carbon machinery steel and give perfect satisfaction where they are maintained in constant mesh. They are very largely used in the soft condition without treatment of any kind. Where the wear conditions are severe and long service is called for, the gear is case-hardened. An oil treatment is good for any gear. The general trend in common gears at the present time seems to be in the direction of a design adapted to a higher quality of steel than has hitherto been used.

Alloy Steels for Gears.—In alloy steels there are two general classifications to consider—case-hardening and oil-hardening. The uses for which the two classes are best adapted are clearly defined in some cases. Plain carbon steel is used extensively in the case-hardened form, but not for the more severe kinds of service, because the core is very low in tensile strength. With a carbon content running from 0.10 to 0.20 per cent., 80,000 lbs. per sq. in. represents a good average value, which may attain 90,000 lbs. when the carbon content is a maximum. Not only is the tensile strength low, but the hard skin is much more likely to chip off under heavy service than where alloy steels are used. The alloys in most general use are :—

(1) Nickel of 3.5 to 5 per cent. (2) Low-grade nickel-chrome, with, say, nickel 1.5 per cent.; chromium, 0.5 per cent.; carbon as desired. (3) Chrome-nickels with either carbon 0.15 per cent., chromium 1.50 per cent., and nickel 3.5 per cent.; or carbon 0.15 per cent., nickel 3 per cent., and chromium not less than 0.60 per cent. (4) Chrome-vanadium steels. All of these alloys are good, depending on the service. The nickels (1) are very good, especially the higher nickels running up to 4 to 5 per cent. nickel. The natural alloy (2) is the cheapest, but least reliable. Chrome-nickels give excellent results. Chrome-vanadium compositions are probably more successful for case-hardening purposes than oil-hardening. An important point to bear in mind is that the lower the quenching temperature that can be used to get an effective hardness the better the result. Chrome-vanadiums require the highest quench of all. For case hardening it is not well to go above 0.20 per cent. carbon in any of the above. All the alloys are more difficult to machine than straight carbon steel. In fact, it may be said that it is quite probable that machineability is a criterion, in inverse ratio, of the value of a steel for gears. Wearing qualities and machineability are to a certain extent inter-related, both being functions of toughness as well as hardness. Another point to be considered is that the low-carbon case-hardening grades in any of the alloys are easier to machine than the higher carbon oil-hardening grades. The greater ease with which they can be machined reduces the cost. All the alloys will stand drop-forging at high temperatures. The ordinary carbon steel is the most readily forged of all and will stand a high forging heat better.

Heat Treatment.—The value of the alloys in steel is quite largely due to the fact that they make steel more sensitive to heat treatment. The higher the forging temperature, the poorer is the heat treatment due to the forging. With the non-sensitive steels this poor heat treatment is not a serious consideration, but where sensitive steels are involved it may put them in such condition as to make them absolutely unfit for service. In any case the harm done will require subsequent corrective treatments, which are more or less profound according to the severity of the forging treatment, *i.e.*, the finishing temperature of the steel at which the steel leaves the forge. The alloy steels will stand a forging temperature of 2,200 deg. Fah., but they must be finished at a low temperature.

Treatment after Carburising.—The treatments that are advisable after carburising are variable. With plain-carbon case-hardening steels it is often possible to get sufficiently good results by a single quench direct from the carburising operation, but this is poor practice. It is better to cool slowly from the carburising temperature and then re-heat for hardening. This especially holds good if the carburising temperature is high. With a low carburising temperature, under 1,600 deg. Fah., it is possible to get successful results with a single quench in the subsequent hardening. In the case of sensitive steels it is necessary to cool slowly from the carburising temperature and re-heat, and still better to give them a double quench. With the highest grades it is impossible to secure the best results without a double quench. In the best practice the resulting core tensile strength from the treatments will probably be highest in the case of the chrome-nickels, and approximate 200,000 to 225,000 lbs. per sq. in.

* Abstract of Paper presented at the recent annual meeting of the American Drop Forge Association at Buffalo. The author is with the Midvale Steel and Ordnance Company, Philadelphia.

Chrome-vanadium and high nickel compositions will approach this strength quite closely. In any case the higher the carbon content of any of the alloys, the higher the range of tensile strength and elastic limits. The elastic limit will more nearly approach the tensile strength in the case of the chrome-nickels than either the chrome-vanadiums or nickel steels. In using case-hardening steels it must not be forgotten that certain parts are not to be hardened, and it is necessary to protect them during the carburising process. Copper-plating seems to be the most effectual method of accomplishing this. The hardness of case-hardened teeth will run about the same, regardless of the material used, but the alloys combine toughness with the hardness so that the teeth will stand harder usage.

Oil-Hardening Steels.—Alloy steels that are suitable for oil-hardening include the following:—(1) Straight-nickel steels with higher carbon contents; 3.50 per cent. nickel is the most generally used for oil-hardening. (2) The various chrome-nickels in the higher carbons. (3) Chrome-vanadium compositions. (4) Other alloys containing combinations of tungsten with or without nickel, chromium, vanadium, etc., have been experimented with, but have never come into general use. The heat treatments vary according to the sensitiveness of the materials, the more sensitive, such as nickel-chrome compositions, requiring a double treatment. The first requirement is a preliminary treatment, which may be a quench or an anneal, to break down the crystallisation set up during forging and bring the steel to a uniform cell size though not a thorough grain refinement. In addition to the above it has been found desirable in the case of some alloys to give them a quench from the forging temperature, in order to improve the condition of the steel, which is apt to be poor. The forgings are taken direct from the forge and dipped into oil or water until they become black, but not cold, and are then buried in ashes. This is a treatment of the cheapest kind and interferes with production only in so far as the necessity for storage space is concerned. The final treatment is for the purpose of producing as nearly perfect grain refinement as is commercially possible. It should be given at the lowest temperature that can be used and still give hardness. As in the case of the case-hardening steels, the relative order for hardening temperatures is as follows:—Nickel steels can be successfully hardened at the lowest temperatures. Then come the chrome-nickels, which have a higher treating temperature; this, however, decreases and approaches those of the nickel steels as the nickel content increases. The chrome-vanadiums require the highest temperatures of all, and while they will give results that are good, the high-treating temperature required is apt to cause trouble from warpage and deformation. The temperature for the final treatment must be above the critical temperature of the steel.

Case-Hardened v. Oil-Hardened Gears.—As to the relative merits of case-hardening and oil-hardening compositions, in certain kinds of service the case-hardened gears are undoubtedly superior, while in others the oil-hardened are best. As a general rule the oil-hardened gear can be counted on for steady uniform wear. Where a case-hardened gear is used, the wearing down of the hard skin to the core at any point means that the gear has gone. Oil-hardened gears always give a lower scleroscope hardness than case-hardened gears, but this is not a criterion of wearing quality. For certain classes of service in certain gear design in automobile work, chrome-nickel oil-hardened gears, having a scleroscopic hardness of 70 to 75, have been found to give satisfactory results, while in others 65 to 70 has proved better. The design is a very important factor in all cases.

In determining the best treatment to give gears there is an important rule to bear in mind, that experiments should be made, using samples of the material of the same size and general shape as the finished gear. Small test pieces do not give conclusive evidence, although they may be useful. The selection of a steel for a gear is a matter of careful study of all the conditions to be met with.

Report on Scientific and Industrial Research.

The third annual report of the Research Department established by the Government for the purpose of encouraging research and assisting the scientific investigation of industrial problems has now been issued for the year 1917-18.

The Report of the Committee of the Privy Council for Scientific and Industrial Research, which precedes the report of the Advisory Council, contains a summary of the year's expenditure, and of the more important questions of policy involved.

As from April 1 last the Privy Council assumed responsibility for the maintenance and development of the National Physical Laboratory, and, with the sanction of the Treasury, have introduced the amended scheme of salaries recommended by the Executive Committee of the Laboratory. They have also approved extensions of the Laboratory which will enable it to undertake the testing of the higher grades of chemical glass and the testing of all clinical thermometers, whether for military or civilian use. A Research Board under the chairmanship of Sir Lionel Phillips, Bart., has been establish to continue and develop the researches into the production of tin and tungsten in Cornwall hitherto conducted, with the aid of a grant from the Department, by the Institution of Mining and Metallurgy. A number of other important investigations by the Department have been sanctioned.

Satisfactory progress has been made during the past year with the negotiations between the Department and the industries of the country for the establishment of Industrial Research Associations. Model Articles which have been approved by the Board of Trade, together with an amended draft of the model memorandum, given in the Council's last report, are printed in an Appendix. The fact is emphasised that it is open to an industry to establish an approved Association without seeking assistance from Parliamentry funds, and Associations of this kind will have exactly the same privileges and will receive the same assistance in the way of advice and information as Associations in receipt of grant. The Department has found in the course of its conversations with leading manufacturers that there is sometimes a certain hesitancy to establish relationship with the Government for the purposes of research, because they fear that the Department will interfere in the work of the new Associations, and will use its powers in such a way as to prevent the results of research from reaching the firms which have subscribed to its cost, or to give the results to competing firms which have not joined or have left the Association. In general they seem inclined to believe that they are being invited to submit to a departmental yoke, which, especially if it is embellished with gold, will grow heavier and fit closer as time goes on, until at last the too complacent trade will find itself harnessed to the Government car, and led, if not driven, at the will of the paymaster. Such an issue would be fatal to the success of the scheme, and entirely opposed to the policy the Advisory Council have formulated and the Privy Council have approved. The intention is that the Associations shall manage their own affairs and benefit by their own discoveries. It is believed that the Department can help each by keeping it in touch with the

work of the rest; that the limitation of Government grants in all ordinary cases to a short period of years, and the provision under which an Association can either forego grants altogether or abandon them at any time, are evidences of the intention. The power of the Department to interfere in cases in which the national interest is concerned, or in which the funds provided by Parliament are not being used for the purposes for which they were granted, is the minimum safeguard that a democratic country could require. But if the firms in an industry will undertake research either for themselves or in combination on any other plan which they think better suited to their needs, they will as certainly receive the sympathetic consideration of the Department and such assistance as is in its power to render. It has never been thought that the Industrial Research Association would meet the case of all industries. But the receipt of public funds must entail the performance of public duties, and for these the Department must have a care.

Report of the Advisory Council.—The first part of the report of the Advisory Council deals mainly with the progress which is being made in the establishment of Research Associations by industries which are preparing to undertake co-operative scientific research for the benefit of members of the Association. Some thirty industries are doing preliminary work with this object. The report states that the movement towards the formation of Research Associations is very encouraging, but naturally it is not yet sufficiently advanced to enable knowledge to be communicated from industry to industry. A start, however, has been made at co-ordinating the means of distributing information amongst a number of closely related but separate industries by the award of a grant from the Department to the Textile Institute.

The financial arrangements of two Research Associations call for special mention. The Iron Manufacturers' Research Association (which now represents 97 per cent. of the industry) has subscribed the whole of the funds necessary without asking for any direct Government grants. By forming an approved Research Association, however, its members derive indirect financial benefit through their subscriptions being regarded by the Inland Revenue Authorities as "business costs." On the other hand, the Department has guaranteed a total expenditure by the Scientific Instrument Research Association of not more than £40,000 during the next five years on condition that the members of the Association make a contribution of £4,000 from their net revenue during the same period, and make no claim for any remission of taxation. This step has been taken because this group of industries falls into the class of "key" industries, and is in urgent need of research on a large scale.

The negotiations of the Department with large groups of manufacturers have led to several important conclusions:—

(*a*) It is only possible to secure co-operation amongst firms which are conscious of the existence of a number of unsolved problems of common interest either to all or to a majority of them. Thus, the attempt to combine in a Research Association the makers of all types of internal-combustion engines was not successful, although it was agreed that research as a co-operative basis is necessary. Similarly the movement for forming a Research Association including both makers and users of refractories has made slow progress. In each case, however, it is probable that separate Associations representing sections of each of these branches of industry will be formed, and that the various sections will unite for joint action on matters of common interest.

(*b*) It has been found that while highly localised industries are capable of organisation into Research Associations with little administrative difficulty, there are many others which are so widely distributed that local committees are needed in order to focus local interest and to secure local initiative in the concentration of effort towards a single administrative control.

(*c*) There is abundant evidence of the increasing realisation of the need for organised research in connection with industry, and it is certain that the movement towards this will receive a serious set-back if the supply of research workers cannot be maintained in proportion to the increasing demands. The report therefore again contains a grave warning of this danger, and states that the Department regards the expenditure in grants to students and to other research workers as being of the first importance. It points out, however, that the responsibility for recruiting the army of research workers lies upon the Educational Authorities of the country, and quotes with hearty agreement the conclusion arrived at by the Committee appointed to inquire into the position of Natural Science in the Educational System of Great Britain.

Arrangements have been made for the co-ordination of the work of the Research Department with that of the Standing Joint Industrial Councils, which are being established as a result of the Whitley Report, an agreement having been made that the Department will consult the Joint Industrial Council of an industry, where one exists, before setting up a Research Association for that industry.

One of the most interesting developments during the year has been the formation, with the help of the Medical Research Committee, of an Industrial Fatigue Research Board, whose function is to consider and investigate the relations of the hours of labour and other conditions of employment, including methods of work, to the production of industrial fatigue, having regard both to industrial efficiency and to the preservation of health amongst the workers.

Systematic surveys of the fields of research are being made in various directions, surveys having been undertaken on the sources and methods of obtaining zinc, on lubricants, and on illuminating engineering.

The report ends by describing the method of awarding grants to students and research workers.

Collection of Controlled Scrap.

The Ministry of Munitions announces that a large number of metal merchants have been authorised to purchase and collect controlled scrap metals in quantities below those scheduled in the Prevention of Crimes Act, 1871, and all persons having in their possession small quantities of scrap copper and lead are requested to dispose of the same to one of the duly authorised merchants as early as possible.

Collecting merchants who desire to be authorised to collect scrap in small quantities should apply to the Controller of Non-Ferrous Materials Supply, Room 620, 8, Northumberland Avenue, W.C.2

The Manufacture of Basic Steel.

The "Journal of the Iron and Steel Trades Confederation" gives the following description of an invention of Mr. A. E. Davies, of Spring Vale.

Since the introduction of the basic open-hearth process many modifications have attained importance, but in each the elimination of the impurities is obtained by the refining action of a basic slag *floating on the metallic bath*. In the process about to be described advantage is obtained by coating the basic bath lining with a layer of highly-heated slag of a rich, limey and oxidising nature, which slowly liquefies when the charge of molten pig-iron is poured upon it, and consequently works up *through* the metallic bath and afterwards still continues its oxidising and refining action while floating upon the surface. The great advantage of innumerable small streams or globules of molten slag rising up through the metal will be at once apparent when it is realised what an immense area of rich oxidising slag is exposed with an ever-changing surface to the action of the metal, causing an intensely rapid and searching reaction in a manner somewhat analogous to the action of the air in the Bessemer process

In operating this improved process the first charge only of molten metal is worked in the usual manner by suitable additions of lime, ore, metallic oxides, etc., to form a slag, and the furnace is maintained at a low temperature (not greatly exceeding the melting point of pig-iron) until the whole of the silicon is oxidised and the phosphorus is only present to the extent of about 0.1 per cent. to 0.3 per cent., the carbon content being about 2 per cent. (NOTE.—The low temperature greatly favours the elimination of silicon and phosphorus early in the process.) The furnace is tilted and the slag poured off into a suitable receptacle, to be afterwards utilised as a fertiliser.

It must be understood that the above method of working the primary portion of the refining is only used for the first charge of metal which is used in starting up the furnace. All other subsequent charges are worked in an entirely different manner, which forms the essence of the present invention. In order to finish the refining of the steel, lime and ore or oxides are now added in sufficient quantity to form a very highly basic and oxidising slag, which reacts upon the already partially refined metal. The remaining 0.1 to 0.3 per cent. of phosphorus is rapidly oxidised, and readily combines with the clean secondary basic slag, while the carbon is also oxidised by the ore and oxides contained in the slag. The percentage of lime in the slag is kept well up, in order to prevent phosphorus passing back from slag to metal, and at the same time any sulphur which may be present is easily removed by carrying 50 to 55 per cent. of lime in the slag. Additional desulphurising agents may be added if the metal is known to be high in sulphur.

The quantity of slag which is made in this part of the process is not kept down for economy's sake to the lowest limit required for the refining process, but is increased by generous additions of lime and oxides, which will be available for working the subsequent charge of molten metal, for which it is intended to be used. This point is important, as the possibility of using a large excess of lime, iron oxide, manganese oxide, etc., knowing that these materials will be used again, greatly increases the rapidity and certainty of the final refining action.

When the steel is refined to the quality desired and is of the right tapping temperature the furnace is tilted to the correct angle to allow of all the steel being tapped out *without allowing the slag to escape*, the necessary "physic"—ferro-manganese, ferro-silicon, etc.—being added to the steel in the ladle in the usual manner. The steel is then run into moulds. The furnace is now tilted back and (the slag not having been allowed to escape) the tap-hole is found to be in a clean and good condition and is easily made secure. Further additions of lime, oxides, etc., are then made to the hot fluid slag lying at the bottom of the furnace, making it still more basic and oxidising and causing it to assume a semi-fluid or pasty condition. This thickened slag is now coated on to the bottom and sides of the furnace lining by tilting the furnace backwards and forwards until it adheres.

On pouring the charge of molten pig-iron from the blast furnace or mixer into the furnace, a vigorous reaction at once ensues, on account of the great oxidising area of the hot slag coating, added to the contact of numerous streams and globules of slag rising through the metal to the top, where it still continues its oxidising and refining action, as before explained.

It will be seen that this stage of the process now, and in all subsequent charges, replaces the old and much slower primary process which of necessity had to be used in starting up the furnace. The steel is thus partially refined at an extremely rapid rate to the point when it contains about 0.1 to 0.3 per cent. of phosphorus and 2 per cent. of carbon, while a large proportion of the slag-forming material which has effected this refining has been utilised, instead of being thrown away as an almost useless slag. The slag, which is extremely rich in phosphoric acid, and therefore very valuable, containing as it does in a small bulk practically the whole of the phosphorus formerly contained in the metal, is then tapped off as before, leaving the partially-refined molten metal in the furnace, and a clean, new basic slag is formed in the furnace by suitable additions in order to oxidise and remove the remaining impurities, and also to provide the slag coating for the next charge before described. The two alternating stages of the process are thus repeated until it is desired to stop the furnace for repairs or other reasons.

The advantages claimed for this improved slag-coating process may be summarised as follows:—

(1) Increased yield by the reduction of iron from the oxides contained in the slag retained in the furnace, and also from the shotted metal contained in this slag.

(2) Reduction of manganese from the slag (and consequent addition of same to the steel) when manganese ore is used in the secondary refining charge as a desulphuriser.

(3) A saving in the amount of ferro-manganese used in the ladle as a deoxidiser or "physic," owing to the quantity reduced from the ore which is contained in the finishing slag if desired. This reduced manganese partly covers the oxidisation of the iron in the bath of metal, and so less manganese is required in the ladle. Any excess of manganese contained in the finishing slag is not wasted, as it does useful work afterwards in the primary refining.

NOTE.—In this process the manganese content of the original pig-iron is of no consequence, since

deoxidation is of no account until the finishing period. If a metal low in manganese is obtained from the blast furnace or mixer, the difficulty can be got over by feeding the requisite amount of manganese ores into the finishing slag. The manganese thus added does double duty: firstly, in the secondary finishing stage; and, secondly, as a refining agent in the slag coating of the primary stage. A wider choice of pig metal is therefore admissible, as in this process all the metalloids are under control.

(4) A great saving of lime and oxides in the slags, as any excess in the secondary slag is used up again in the primary stage.

(5) No slag is wasted or thrown away. The phosphoric acid in the secondary slag is all recovered and concentrated in the primary slag. Consequently a very valuable fertilising slag, containing a high percentage of soluble phosphoric acid, is made at each cast.

(6) The ingots being cast free from slag, less scrap is made in the rolling mills. The ingots roll more solid and the bars are truer to section, with less surface defects, such as "hollow ends, slag-pitted surfaces, laminations, spills," etc. This freedom from slag in the ladle also prevents the phosphorus "passing back" through the reduction of phosphorus from the slag by the carbon after the ferro-manganese has been added.

(7) A great saving in time, and consequently of fuel, furnace materials, etc. In ordinary working there is always a wait of two or three hours in the early part of the process in order for the lime and oxides to get into solution to form a slag.

Normalising of Carbon Steel.

For the production of gauges, Automatic and Electric Furnaces, Limited, of 6, Old Queen Street, Westminster, S.W.1, in a printed circular sent to us, recommend the use of a good-quality annealed carbon tool steel having a carbon content, say, 1.2 per cent. to 1.5 per cent., with manganese —under 0.5 per cent. The correct normalising of the steel is a matter of importance. To heat simply in a muffle or salt bath, judging the temperature by pyrometer, too often results in scrapping the material. It is at this stage that future success or failure is determined. It must be borne in mind that the annealing process as carried out has two results, the first is chiefly to remove the original strains in the metal, and the second to coarsen the grain. The process of normalising removes certain strains which have been re-introduced, and, at the same time it produces the finest possible grain, and so reduces the steel to its best state for fine and sweet cutting, which not only ensures a better output, but also tends to lengthen considerably the useful life of the cutting tools.

The gauge to be treated should first be blanked out and then placed in the furnace. The heating should be uniform, and consequently it is not advisable to use an ordinary muffle. The most suitable heating medium is a salt bath; but the essence of the whole treatment, upon which everything depends, is the correct temperature to which the work should be heated, and the tool or blank should be taken out immediately the steel has passed through its critical point, and cooled in the air. A temperature higher or lower than the actual point for the grade of steel under treatment results in a coarse crystalline grain, more difficult to work and uncertain to harden. It is necessary, therefore, to adopt a method of determining with certainty what the correct temperature should be, and in order to achieve this result the firm have developed a pyroscopic detector to give the operator immediate and automatic notification of the change point, irrespective of the carbon content of the steel. Steel heat-treated under these conditions shows remarkable improvements, and has great advantages over that normalised by the usual methods; and the final heat treatment can be carried out with a certainty that successful results will be obtained and considerable increase in output assured. Experiments conducted with gauges normalised under ordinary workshop conditions, *i.e.*, heated in a furnace and the temperature checked by pyrometer, compared with those normalised in the Wild-Barfield furnace with a pyroscopic detector are stated to have completely proved the importance of this process of correct and simple normalising. The cooling in air results in the formation of a thin skin of oxide, which if left on has a deleterious effect upon the tool used for finishing. It is, therefore, advisable to remove it by lapping with carborundum powder (FFF) and vaseline. About two runs with the lap should be sufficient to remove the oxide. It will then be found that the steel cuts very smoothly and easily, and that wear is reduced to a minimum.

ELECTRIC FURNACE FOR BRASS.—The U.S. Bureau of Mines has developed a new type of electric furnace for melting brass, that may perhaps be employed for other purposes. Free licences to operate under the patents held by the Bureau can be obtained by making application through Mr. Van H. Manning, Director of the Bureau. The new furnace, it is claimed, will reduce losses in brass melting, especially the loss of zinc. Zinc boils at a much lower temperature than copper, and thus there have been large losses in the open crucible furnace through volatilisation of the zinc. The electric furnace is closed, and these losses are avoided. It is estimated that the unnecessary losses in brass making are more than £600,000 a year in normal times in the States, and perhaps £2,000,000 a year in war times. Another claim for the electric furnace is that it gives more healthful working conditions for the men.

HIGH-SPEED STEEL.—Mr. J. L. Thorne recently discussed high-speed steel before the Steel Treating Research Society of Detroit. American steels, he suggests, should not be bought by trade name only, since there have been instances where the composition has been materially changed without notice to users. The high-speed steels on the American market are now comprised within the following limits, the last column giving a good chemical specification :—

	Range per cent.	Proposed per cent.
Carbon	0.47 to 0.91	0.65
Silicon	0.12 to 5.00	0.12
Manganese	0.12 to 0.67	0.25
Sulphur	0.008 to 0.057	0.02
Phosphorus	0.006 to 0.051	0.02
Chromium	1.50 to 5.52	3.50
Vanadium	0.13 to 2.50	1.00
Tungsten	11.71 to 22.27	18.00

New high-speed stock should have a hardness slightly under Brinell 250 or scleroscope 35 in order that it may be machined readily. A microscopic examination should also be made before the material is accepted, looking particularly for forging cracks, surface decarbonisation, uniform structure, segregation and ingotism. In extensive tests of nearly a thousand drills made of all available American and other high-speed steels, it was found that the most efficient tools exhibited a great resemblance in microscopic structure, regardless of their manufacture or heat treatment. This has led to the adoption of the so-called "standard structure," to be looked for in trying to discover the proper heat treatment to give a new lot of tool steel. Start with several samples, and subject them to various temperatures for various times approximating the expected conditions. A microscopic examination will then show the one which nearest approaches the standard structure.

New Melting and Re-Heating Furnace.

The regenerator furnace illustrated has been designed and patented by Mr. Wallace Bache, Main Street, Bishopriggs, Glasgow. Mr. Bache has for some time been engaged upon the construction of copper-smelting furnaces for a large works in North Britain, so that the furnace which we illustrate has been designed more especially for copper smelting. The form of construction is such, however, as to be readily adaptable for any and every form of heat treatment.

The furnace is so constructed with hollow regenerator bricks that the firebox is below the furnace, whilst the products of combustion therefrom pass along gas flues below the furnace bed and mix with hot entering air from the regenerator bricks, passing to a combustion chamber and over the furnace bed to flues, from which they pass through sets of regenerator bricks, and thence to the chimney. The furnace is adapted to be fired with solid fuel, coal, slack, and the like.

When the furnace is in use the fuel is fed into the firebox A through the fire door. An open water tank is placed beneath the firebox, and a pipe for supplying water to the fuel above the firebars is also provided. The air for combustion purposes is conducted to the firebox through the air ducts B. In order to start combustion a full supply of air is delivered to the firebox through the ducts referred to, but when the furnace is sufficiently heated the air supply is so reduced that very imperfect combustion takes place in the firebox, and the products pass by means of the gas flues C to the combustion chamber D. At the same time water is supplied to the fuel in the firebox by the pipe shown, and water gas is thereby generated which mixes with and augments the gases from the fuel for com-

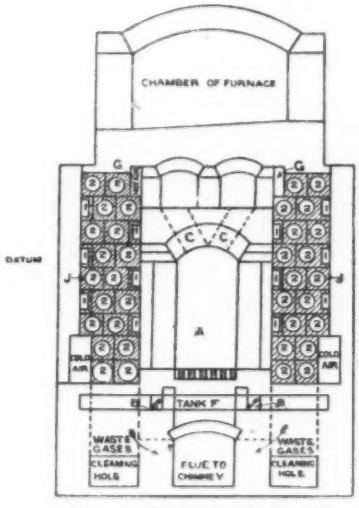


FIG. 1.—Front Elevation. (The figures 1 and 2 indicate air and gas respectively).

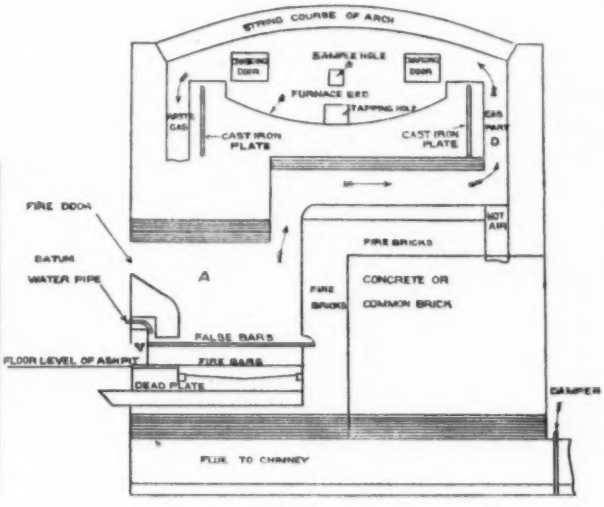


FIG. 2.—Side Elevation, showing Bed of Furnace, Firebox and Course of Gases.

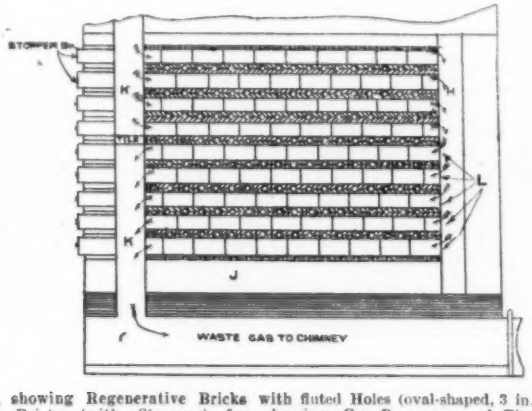


FIG. 3.—Side Elevation, showing Regenerative Bricks with fluted Holes (oval-shaped, 3 in. 2 in.) for Air Passages; also hollow Bricks (with Stoppers) for cleaning Gas Passages, and Tile for Division.

NEW MELTING AND RE-HEATING FURNACE.

bustion in the combustion chamber. The water in the water tank below the firebars is likewise vaporised and, passing through the fuel, further augments the combustible gases. When the gases reach the combustion chamber they meet with highly heated currents of air from the hot air flues G, and thus produce a highly combustible gas, which immediately bursts into flame. This flame passes from the combustion chamber over the furnace bed, while the waste gases pass by means of the flues H to the regenerative bricks J, which are made hollow, as shown in the enlarged view, Fig. 4.

It will be seen on reference to Fig. 4 that the regenerative brick, in addition to the hollow passage-way M, is provided with transverse grooves N on its upper and lower sides. The effect of building up a number of courses of such bricks is clearly shown in Fig. 3. The transverse grooves in each brick coincide with the corresponding grooves in the courses above and below, and constitute transverse passages, through which the air is caused to travel before reaching the combustion chamber. Referring to Fig. 3, the track of the waste gases through the courses of regenerator bricks will be made clear. On passing from the furnace bed the waste gases descend through the flues K, and pass through the four upper courses of regenerator bricks to the rear end of the furnace, from whence they pass by means of the flues L through the five lower courses of bricks through the flue K to the chimney flue, which last is provided with a suitable damper. For the direction of the waste gases through the regenerator bricks a division, by means of a tile, is made in each waste-gas flue. By this means these flues are closed, thus directing the waste gases through the bricks in the manner described. The bricks thus become highly heated and impart their heat to the cold air drawn into the furnace for combustion purposes as follows. As will be seen on reference to our illustrations, the cold air ducts are arranged one on each side of the furnace, and they extend upward to a height equal to two courses of the regenerator bricks. By means of the transverse grooves in the bricks the cold air is caused to pass between each course, and, travelling in a serpentine fashion, reaches the top course of bricks, from whence it passes to the combustion chamber in a highly heated condition. To facilitate the passage of the air being heated hollow bricks are provided at intervals in each course of regenerator bricks. The passages between the courses are easily accessible for cleaning, and suitable provision is also made for cleaning the fire.

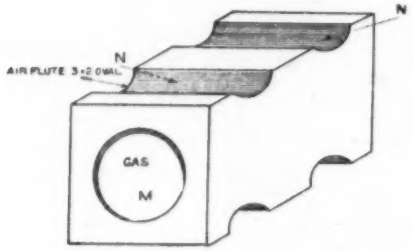


FIG. 4.—THE BACHE REGENERATIVE BRICK.

The outer walls of the furnace are concrete, and the whole is strapped together by means of double-channel beams, whilst the furnace bed is stiffened and strengthened by cast-iron plates.

Electric Melting of Brass.

Mr. H. M. St. John, of the Commonwealth Edison Company, Chicago, says the application of direct arc furnaces to copper alloy melting has been rather limited, no new types being developed for this work. No form of the general type has ever been satisfactory in melting brass or other copper alloys containing an appreciable percentage of zinc. The indirect arc furnace is somewhat more complicated, and its thermal efficiency is not so high, but in the melting of copper alloys it can be used in larger units and seems more satisfactory. In a new type of indirect arc furnace the metal as soon as it becomes molten is agitated by the rocking of the furnace in order to avoid the overheating of the surface layer. In this type the non-uniformity of heating is largely rectified, and alloys high in zinc can be melted without excessive loss. Referring particularly to the present status of the electric furnace for melting non-ferrous metals, Mr. St. John said there are four types of furnaces in commercial use for melting copper alloys, and of these only two are suitable for use in alloys high in zinc. One, the vertical ring induction furnace is of high efficiency, but somewhat limited as to its application and not sufficiently flexible for general foundry use, but gives very satisfactory results within its limited range. The indirect resistance, indirect radiation furnace is less efficient and has a lower rate of output in proportion to its holding capacity, but it is more flexible and better suited for general foundry use. However, neither of these types can be classed as entirely satisfactory. The indirect arc furnace is in use for melting alloys containing no zinc, or a very small percentage of zinc. This is more efficient than the indirect resistance furnace, and within its field more flexible than the induction furnace. The direct arc furnace is being used to a limited extent for melting copper alloys which contain no zinc. Present conditions make it profitable in some cases, but its continued application is not insured.

REFRACTORY MATERIALS AND THE ELECTRIC FURNACE.—At the recent meeting of the Refractory Materials Section of the Ceramic Society, at Sheffield, Dr. R. S. Hutton submitted a "Note on Electric Furnace Treatment of Refractories," in which he pleaded for the application of the electric furnace to the study of refractory materials, with a view to the manufacture of new articles from materials that at present are not easily fusible. He pointed out that the temperature of the open-hearth steel furnace is about 1,650 deg. C., and that refractories in general use for the construction of these furnaces are seldom produced or tested under much higher temperatures. Attempts should be encouraged to provide a higher "margin of safety" for the refractories now demanded for fuel-heated furnaces. One of the chief hindrances to rapid progress lay undoubtedly in the fact that so many investigators were limited to temperatures obtainable with fuel heating, and far too little seemed to have been done, and to be in progress of applying, in works or laboratory, the electric furnace to the preparation of raw material, and the firing of products made from such material. Was it too much to hope that in a short time material would be available, in the form of bricks and other products, made from highly refractory material, and guaranteed as having been subsequently fired, in its formed state, at 2,000 deg. C.? Another author, Mr. W. J. Rees (Sheffield University), in "A Note on a Firebrick from the Crown of an Electric Steel Furnace," described the excellent behaviour of a brick made from the refractory clay of North-West Ayrshire. The brick stood 145 charges in a half-ton furnace. A second crown of the same material had stood well above 100 charges, and was still giving good service. Unquestionably the clay referred to had valuable refractory properties.

Large Jolt-Ram, Turnover, Pattern-Drawing Moulding Machine.

The machine illustrated, recently built by Messrs. John Macdonald & Son, Limited, Maryhill, Glasgow, to the order of a firm in the North, for moulding the centres of locomotive wheels, is the largest of its kind in this country. The table will take boxes up to 8 ft. sq. or 8 ft. in dia. There is a clear space of 4 ft. 2½ in. between the tables and patterns up to 15 in. deep can be drawn. The machine occupies a floor space of 17 ft. × 12 ft., and has an overall height of 6 ft. 1½ in. with the table in the ramming position and the base of the machine standing at floor level, whilst the total weight is approximately 25 tons. Under normal working conditions, wheels 6 ft. 6 in. in dia. × 12 in. deep (inside measurement of mould box 7 ft. 10 in.) are rammed in 15 secs., in which period of time the mould receives 30 jolts, 2 in. stroke. The total air consumption for the complete operation, including lifting and drawing, is 65 cub. ft. at 80 lbs. pressure.

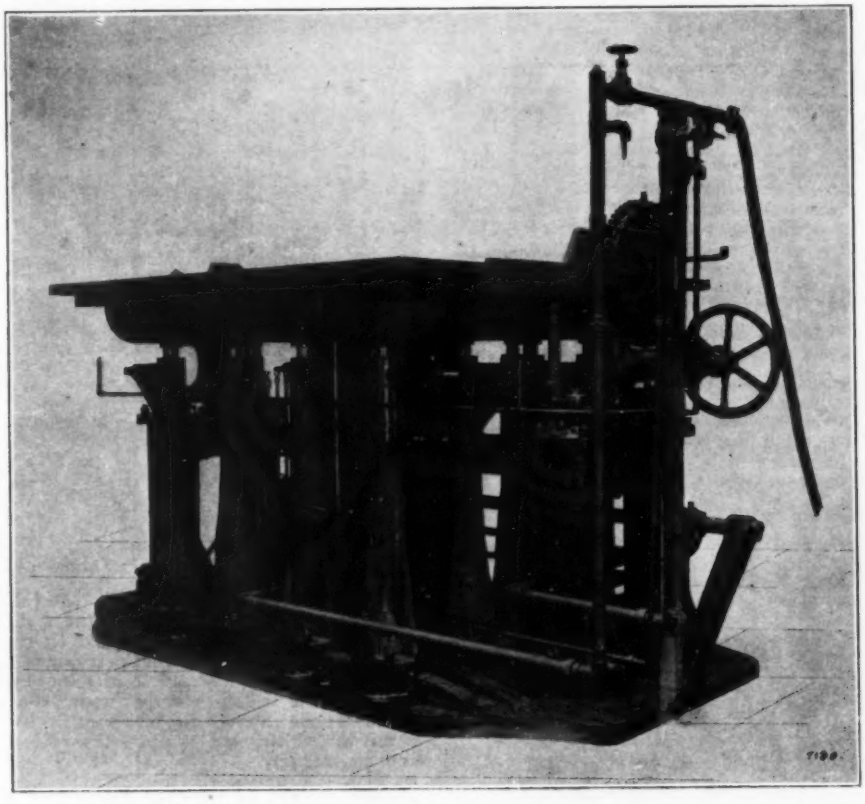


FIG. 1.—"AJAX" MOULDING MACHINE. (NOTE CLEARANCE BETWEEN WORM AND WORM WHEEL.)

The lower table of the machine is carried upon a 20-in. dia. ram, the jolting impact being taken upon 12 steel studs, which are turned to a working fit into the top of substantial cast-iron columns, the bottom of the studs within the columns resting upon fibre cushions, so as to absorb the shock instead of transmitting it through the columns to the base of the machine to which the columns are bolted.

The turnover table is lifted by four 10-in. dia. air cylinders, which are coupled up with rear shafts and side links, thus ensuring unison in action. As a consequence the pattern can be drawn out of the mould by use of the side cylinders, or the mould from the pattern by the centre ram. The turnover table is operated by means of a phosphor-bronze worm-wheel and steel worm, coupled with compound gears, a combination which, with 10 lbs. pressure on the hand wheel, enables a man to turn over a load of 5 tons with the greatest ease. It should be noted that during jolting operations the worm and worm-wheel are entirely out of engagement, their respective positions at such times being clearly shown in our illustration (Fig. 3). This is provided for by carrying the worm shaft on a side bracket secured to the lifting head of the side cylinder in such a manner that the worm is brought into mesh when the raising cylinders are operated, and falls clear immediately the piston of the side cylinder comes to rest. These side cylinders, it may be mentioned, pass through the base of the machine, so that there is still 26 in. of piston within the cylinder even when the table is in the highest position.

The mould carriage track is not shown in our illustrations; this, however, is carried upon the studs which are seen projecting from the sides of the impact columns. The mould carriage, which

is built up of steel channels, connected by steel end brackets, is mounted upon 8 in. wheels, which run on ball bearings.

In the machine illustrated the valve gear is a special feature, and, unlike most of such gears, is entirely independent of the table and is thus free from all possibility of shock. The construction of the jarring valve is of the simplest possible form. The valve lifts against a spring, the force of impact being controlled by means of the regulator placed above the valve. It will also be noted that the inlet valve is entirely closed before the exhaust valve is opened. The essence of the arrangement, however, lies in the pilot valve, which governs the admission of air to the jarring valve, so that no more air is admitted to the ram than is actually required to raise the table. The pilot valve, which is bolted to the jarring valve, consists of an air cylinder provided with a piston, the limit of rise of which against the air pressure is controlled by a stud which projects within the cylinder wall and engages a keyway cut in the piston rod, the full extent of the lift being equal to the jarring stroke—2 in. When under air pressure the head of the pilot piston rod engages with a mushroom-headed screw which forms the end of a rod depending vertically from below the table into which it is screwed; normally, however, the head of the pilot piston rod rests entirely clear of

FIG. 2.—"AJAX" MOULDING MACHINE; TABLE RAISED.

the head of the screw. The operation of the valve is extremely simple; when air is admitted below the pilot valve, its piston rises until it comes into engagement with the mushroom-headed screw; the cock admitting air to the jarring valve is then opened, thus lifting the table and allowing the pilot piston rod to continue to rise for its full length of stroke, in completing which it cuts off the inlet and opens the exhaust of the jarring valve, thus allowing the table to be jolted and completing a cycle of operations.

To eliminate all possibility of accident due to the pilot valve being inadvertently opened when the table is being raised, a by-pass connected with the three-way cock of the lifting cylinders admits air above the jarring valve when the lifting cylinders are put into operation, so that should the pilot valve be accidentally operated no harm would result, as the area under pressure above the valve exceeds that under pressure at the air inlet. When the exhaust is opened for the lifting cylinders, it

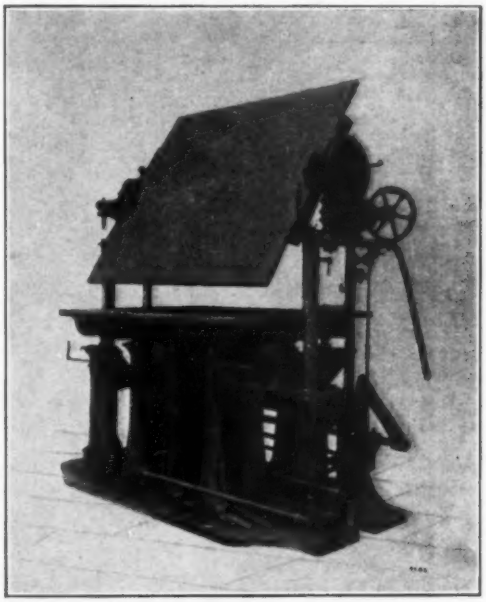


FIG. 3.—"AJAX" MOULDING MACHINE; SHOWING TURNTABLE RAISED AND PARTLY TURNED OVER.

also opens the exhaust to the chamber above the valve. In addition to protecting the machine the arrangement serves to keep the valve tight upon its seat, and so eliminates air leakage which in many machines is a frequent source of annoyance when the table is being carried upon the lifting cylinders; the exhaust also provides for the escape of any air which may leak past the valve into the upper chamber.

TIME LIMITS FOR RAPID CHEMICAL DETERMINATIONS.—In a paper contributed to "The Iron Age," Mr. A. F. Macfarland states that some years of actual experience in the metallurgical laboratory has shown the following time limits quite practicable for rapid determinations without impairing the accuracy of the results obtained. One man performs the analysis, and his time is counted from the moment he receives the drilled sample to the time the written report is ready:—Carbon, 10 to 13 minutes; carbon and manganese, 12 to 14 minutes; carbon, manganese and nickel, 14 to 18 minutes; carbon, manganese, nickel and chromium, 22 to 28 minutes; carbon, manganese and sulphur, 15 to 19 minutes; carbon, manganese, sulphur and phosphorus (estimated), 18 to 24 minutes; carbon, manganese, sulphur, phosphorus, nickel and chromium, 35 to 40 minutes. If other than preliminary tests are analysed in the laboratory, as is usually the case with small steel plants, the chemist should be notified 10 or 15 minutes before the preliminary sample is furnished, to enable him to make the requisite preparations.

"F.T.J." Bookshelf.

Ingots and Ingot Moulds. By ARTHUR W. BREARLEY and HARRY BREARLEY.—London: Longmans, Green & Company, 39, Paternoster Row, E.C.4. (16s. net.)

This book is offered by its authors as "only an imperfect contribution to a difficult subject," and is intended especially for those who, like themselves, are interested in ingots, and engaged in making them. A considerable portion of the volume was prepared for teaching purposes, and during the few years that the MS. sheets were so used, they have been freely criticised by capable men whose business it is to make steel ingots. During this period of incubation a number of opinions formulated tentatively have been confirmed by oft-repeated experiments made on a commercial scale in different steel works, while a number of other opinions have failed to withstand criticism and further experiment, and consequently had to be modified. Incidentally—the authors remark—they are less confident now than they were formerly about their being qualified to elucidate the art of ingot making. But whatever may be urged against the book or any portions of it, the fact, we think, must be recognised that it represents the gist of the accumulated knowledge and matured opinion of two practical Sheffield steelmakers, and must be read as such. After an "Introductory Note" on the use of stearine for teaching purposes, the authors discuss in two chapters crystalline structure and its effects and cavities produced by "shrinkage and contraction," the term "shrinkage" being used for the contraction of the metal in successive layers during solidification, and "contraction" denoting the skrinkage of the ingot as a whole. Casting temperatures and ingot moulds (thick and thin), the care to be taken with them, their shapes and forms, cost and durability are next dealt with in turn. In Germany and Austria, we are told, and also to a lesser extent in England, high-class steel ingots are cast in circular moulds, so that before they are forged surface defects may be removed in the lathe. Circular ingots at any rate, we may point out, have the two advantages of (1) having no sharp corners, and (2) no hollow sides, two fruitful causes of strains due to unequal cooling, and of a tendency to trap surface impurities. The next chapter (VI.) describes the various methods of casting, the pros and cons of top casting and bottom casting direct from the ladle, or with the help of a tun-dish. Sound ingots, blow-holes, segregation and slag "occlusions," are then dealt with, each subject by itself, in separate chapters. Purists, we may remark, like to reserve the word "occlusions" for gases trapped in ingots, and particles of slag to be found in ingots they prefer to call "inclusions." Finally, the influence of ingot defects on forged steel is shown in the last chapter. The book is fully illustrated by diagrams, sulphur prints, etched sections, etc., and will well repay careful study.

Industrial Electro-Metallurgy. By ERIC K. RIDEAL.—London: Baillière, Tindall and Cox, 8, Henrietta Street, Covent Garden, W.C.2 (7s. 6d. net.)

This is another volume in the "Industrial Chemistry" series edited by Dr. Samuel Rideal. In his preface the author, Mr. Eric K. Rideal, considers it a matter of past regret and present concern that electro-chemistry has not yet been raised to the dignified standing of a "subject" in our English higher educational system, except in one or two exceptional cases. As a result electro-chemical considerations, we are told, receive but scant attention, usually being confined to a few lectures in a course covering the whole of physical chemistry. Notwithstanding the fact—we are further told—that there exists an excellent bibliography (collection?) of text books on theoretical electro-chemistry, this lack of a personal element in the teaching has been sufficient to eliminate the English research student from the field. As a result, the English industry has suffered in having either to purchase foreign processes or to waste both time and money in experimental work carried out by investigators ill-equipped with the requisite knowledge. A partial explanation of this is to be found in the author's own Introduction. Electro-metallurgical processes, and more especially electro-thermal processes, require heavy currents at a very low rate, and consequently electro-metallurgy on a commercial scale is at present only carried on in a few favoured localities in this country, where current can be obtained at a comparatively low cost. According to the author's own table, given in the Introduction, the total cost of electric energy per kw.-year at Kinlochleven is 45s. 8d., whereas at Odda and Svaelgfoss in Norway and at Trolhättan in Sweden a kw.-year only costs from 11s. to 12s., and the natural economic selling price of this power (i.e., covering full running costs, depreciation, royalties, and other overhead charges, and leaving a small profit) lies between 25s. and 40s., according to the Report of the Norwegian Royal Commission of 1915. To produce one kw.-year for 40s., the pre-war cost of hydro-electric power, the author estimates that coal would have to be delivered at the power plant for 4s. 3d. per ton. As regards gas, even in the author's very hypothetical case, with coal at 7s. 6d. a ton, a kw.-year with gas-fired boilers and turbo-generators would cost 97s. 8d. or 42s. 10d. dearer than with a coal-fired turbo-generator set; with "somewhat idealistic" conditions, however, as regards the value of by-products obtained in the gasification of coal, the cost of the kw.-year could be reduced to 6s. 2d. below the "average" water-power costs (40s.). With regard to gas engines, the author comes to the conclusion that notwithstanding the apparent advantages in the use of a more efficient prime mover, the limitations in size (3,000-kw. units being the largest so far constructed), together with the heavy installation expenses, would make the working costs and depreciation on machinery more than counterbalance any fuel economy which could be obtained in their case. The Introduction ends with a short review of the metalliferous resources of the British Commonwealth.

In the first three sections following the Introduction the author deals with electrolysis in aqueous solutions (electrolytic recovery of copper from its ores, electric refining of zinc, lead, etc., electro-galvanising, etc.), with electrolysis in fused electrolytes (the extraction of aluminium from its ores among other processes described), and with the electrolytic preparation of rarer metals, while the last five sections are devoted respectively to (1) electro-thermal processes; (2) carborundum, etc.; (3) the carbides; (4) nitrogen fixation; and (5) to iron and ferro-alloys. The last-named subject is disposed of in 32 pages, including the preparation of electrolytic iron, but some of the ferro-alloys (ferro-manganese, ferro-chromium, etc.) are briefly touched upon elsewhere under the different metals forming ferro-alloys.

Social and Industrial Reform. By SIR CHARLES W. MACARA, Bart.—Manchester: Sherratt & Hughes, 34, Cross Street. (5s.)

This volume contains a number of articles on economic subjects, contributed during recent months by Sir Charles Macara in one form or another to various periodicals, such as the "Manchester Guardian," the "Cotton Factory Times," and others. During his long and useful public career Sir Charles, in addition to carrying on the work incident to his position as president of various national and international organisations, has, through the press and otherwise, undertaken a large amount of propaganda work, and having to a large extent relinquished his official positions, he has been able lately to extend his activity in that direction. Some of the articles interest the cotton industry more closely, but there are others of more general interest, such as "A Survey of Present Conditions," "The Conscription of Wealth," "Labour's Post-War Problems," and others. In Appendix IV. the last annual report (1916) issued by the Employers' Parliamentary Association is reprinted, of which Sir Charles is the president.

Trade Talk.

McKechnie Bros., Limited, of Widnes, have removed their Leeds offices to 59, Prudential Buildings, Park Row.

The engineering and foundry business carried on at Carlow by Messrs. T. Richards has been bought by Mr. F. Thompson.

Damage estimated at several thousands of pounds has been caused by a fire at the Lawside Foundry, Dundee, of Messrs. Lee, Croll & Company, engineers.

Messrs. W. E. Hughes & Company, metal and tinplate merchants, have now resumed occupation of their former offices at 50 and 51, Lime Street, London, E.C.3.

Messrs. James Scott, Limited, electrical and mechanical engineers, Bootle, Liverpool, have opened a branch at 4, Great Jackson Street, Hulme, Manchester.

Messrs. Mountford Phillips & Company, Limited, are making extensions to the buildings and plant at their Cambrian Engineering Works, Pontyclun, Glamorgan.

The first steel vessel built in Inverness was launched last month from the slipway of the Rose Street Foundry & Engineering Company at the Thornbush, Inverness.

Messrs. Charles Hatton & Company, tinplate and metal merchants, have removed their offices from 107, Upper Thames Street, E.C., to 5, Fen Court, Fenchurch Street, London, E.C.3.

Messrs. W. Canning & Company have acquired new works and plant at Salop Street, Highgate, Birmingham. Their engineering establishment at Snow Hill was recently destroyed by fire.

Messrs. D. Francis and N. Clayden, engineers, Chatteris, trading under the style of the Chatteris Engineering Works Company, have dissolved partnership. The Chatteris Engineering Company, Limited, have acquired the business.

The Campbell Gas Engine Company, Limited, Halifax, have recently opened a direct branch of its business at C-3, Clive Buildings, Calcutta. The branch is in charge of Mr. H. C. Ward, who has been on the company's technical staff for the past 12 years.

It is stated a valuable discovery has been made on Crown land near Barmouth, of a solid vein of zinc, 2 ft. deep, extending for some distance into the mountain. Samples have been submitted to London with excellent results, and steps are being taken to work the deposits.

It is reported that the British Government has promised its consent to the export of 3,000 tons of shipbuilding material for the New Waterway Shipbuilding Company. This material will, with the consent of the Dutch Government, be used for building one British and one Dutch ship.

Owing to the scarcity of aluminium in Germany, zinc and alloys of zinc have been used as substitutes for copper in many cases. These, it is understood, proved a failure and will have to be changed after the war. Nickel has become very scarce and very little is available for the steel industry.

The electrical machinery required for the first unit of the plant which the Hydro-Electric & Metallurgical Company is putting up at Electrona, near Hobart, for the production of zinc from Tasmanian ores, has been delivered on the site. The company holds the Gillies patent process for the production of zinc.

The Departmental Committee empowered to investigate the position of the iron and steel industry has framed a scheme of commercial reconstruction, a feature of which is that all imports of manufactured or semi-manufactured products should be prohibited from the present enemy countries during the reconstruction period.

Messrs. Ruston, Proctor & Company, Limited, engineers, Lincoln, announce that they have acquired the business of Messrs. Richard Hornsby & Sons, Limited, of Grantham and Stockport, whose extensive works, well equipped with modern plant and machinery, employ over 3,000 workpeople. The new combination will be carried on as Ruston & Hornsby, Limited.

The committee appointed by the Board of Trade to consider applications and hear applicants for licences under the Non-Ferrous Metal Industry Act is meeting regularly and frequently during the recess. The committee has now disposed of some 900 out of a total of 1,400 applications received, and the consideration of the remainder is being rapidly proceeded with.

During the past year about 150 Supervisors of Boy Welfare have been appointed by the managers of munitions factories from the panel of the Welfare Department of the Ministry of Munitions. There is at present room in the factories for further boy welfare supervisors. All information on the subject can be obtained from the Ministry of Munitions (Boys' Welfare Section). Whitehall Gardens, S.W.1.

Several extensions to Glasgow engineering works are intimated. Messrs. Alley & McLellan, Limited, Polmadie, are erecting a foundry and gantry; Messrs. James Howden & Company, Limited, are making additions to their foundry in McLellan Street; Messrs. Allison Brothers, ironfounders, are making alterations to their foundry at Pollokshaws; and Messrs. Ferguson & Timpson are extending their engineering shop in Prince's Street, Govan.

The Lea Shipbuilding and Repairing Yard, situated at Canning Town, E., previously carried on by Messrs. A. W. Robertson & Company as a private concern, has been taken over by a new company, called the Lea Shipbuilding & Repairing Company, Limited. The new company will have a capital of £50,000, in £1 shares, the directors being Messrs. Thomas A. Blane, shipowner, London and Cardiff; Louis J. Bielski, coal exporter, Cardiff; and John Wallace, naval architect. London and Glasgow.

We have received from the Decimal Association (212-213, Finsbury Pavement, London, E.C.2) the first number of "The Decimal Educator," the new official organ of the Association, "established to promote the adoption of a decimal system of coinage, and of the metric system of weights and measures in the United Kingdom." The issue includes short articles, among others, on the history of the Association, one entitled "Arguments for Decimalists," one on the Balfour Report, etc.

The Defence of the Realm Regulations have been amended so as to confer on the Minister of Munitions power to prohibit or to restrict the supply of electricity to any premises where such a step is desirable to maintain or to increase the supply of light, heat, or power for war work. No order is to be made for the closing of any power station belonging to any local authority or for the connection of any such power station with any other power station except with the concurrence of the appropriate Government Department.

The report of Elliott's Metal Company, Limited, states that the purchase of the undertaking of William Cooper & Goode, Limited, has been concluded. The whole of the ordinary and preference shares of the Hughes Stubbs Metal Company, Limited, have been acquired in exchange for ordinary and preference shares of the Elliott's Company. These shares will rank for dividend as from August 4, 1918. Following these acquisitions, Mr. T. W. Horton and Mr. John Stubbs have been elected to seats on the board.

At a meeting of representative manufacturers of milling cutters, recently held at Manchester, it has been decided to form immediately an association to be known as the Milling Cutter Manufacturers' Association, to deal with all matters interesting or affecting the makers of these tools. The Association will be glad to receive applications for membership from bona fide manufacturers of milling cutters, such applications to be addressed to the secretary, Milling Cutter Manufacturers' Association, c.o. Sir W. G. Armstrong, Whitworth & Company, Limited, Openshaw, Manchester.

Owing to the difficulty in procuring steel sheets, Tilghman's Patent Sand Blast Company, Limited, Broadheath, Manchester, are now constructing the walls of the sand blast rooms at their works with cast-iron plates. The plates, which are ½-in. thick and strongly ribbed, made in a standard size of 3 ft. square, are planed all round and bolted together. As in the old form of structure, ¼-in. steel plate was employed, the new rooms are heavier, and also more costly. At the same time, the iron plates make a very substantial job and seem well worth the additional cost.

The Board of Trade draw the attention of all companies, firms and individuals holding licences under the Non-Ferrous Metal Industry Act, 1918, to the fact that these licences do not dispense the holders from complying with the regulations which have been made under the Defence of the Realm Act with respect to the sale or purchase of non-ferrous metals. The necessary permits under these regulations must be obtained from the Ministry of Munitions in respect of any sales or purchases of non-ferrous metals in the same manner as before the licences under the Act were granted.

The annual report of the Staveley Coal & Iron Company, Limited, states that the new blast furnace is in operation, and the erection of a new range of 60 coke ovens has been commenced. In view of these and other extensions, it has been considered advisable to issue fresh capital, and an opportunity has been given to shareholders to subscribe for one new £1 share at a premium of 10s. per share for each five fully-paid shares and proportionately for the partly-paid shares held by them. These new shares will rank for dividend on the amount called up as from July 1 last.

An Inter-Allied Tin Executive has been established to sit in London to control the price and distribution of tin for the Allies. The various countries will be represented as follows:—Great Britain.—Sir Leonard W. Llewelyn, Controller of Raw Materials Department, Ministry of Munitions; Mr. W. A. Tennant, Tin Controller, Ministry of Munitions. United States.—Mr. G. M. Armsby, head of the War Industries Board (Tin Section); Mr. J. Hughes, American Iron and Steel Institute. France.—Lieutenant Sauvage. Italy.—Colonel Riggi. The secretary is Mr. H. A. Buck, secretary of the London Metal Exchange.

The large expenditure incurred in the expansion of the business of J. Brockhouse & Company, Limited, of West Bromwich, and the necessity of providing large sums for development, extension of premises and plant, have rendered the present issued capital inadequate for the requirements of the business. The directors have decided, subject to the sanction of the Treasury being obtained, to make a new issue of capital, and to invite the holders of ordinary shares to apply for the whole of the proposed new issue. The proposed new issue will be of 57,000 ordinary shares of £1 each, ranking in all respect with the ordinary shares already issued and ranking for dividend as from July 1 last. The new shares will be issued at £1 10s. per share.

The list of shareholders to the capital of the new London Iron and Steel Exchange includes the following, who each hold 50 shares of £1 each:—Messrs. H. B. Barnard & Sons, Bolling & Lowe, Brown & Tawse, Limited, Brooker Dore & Company, J. & J. Drysdale & Company, Dutton Massey & Company, Moss Isaacs, Limited, W. Jacks & Company (East India Avenue), A. G. Kidston & Company, E. Lloyd & Company, Redpath Brown & Company, Miles Druce & Company, H J. Skelton & Company, Limited, Watson Slack, Bailey Toms & Company, G. Warren & Company, Grovesend Steel & Tinplate Company, H. W. Peabody & Company, A. Campbell, Rownson Drew & Clydesdale, Limited, W. J. Firth, A. Cameron & Company, N. Hingley & Sons, Limited, Hughes & Company, Yates & Company, J Summers & Sons, T. W. Ward, Limited, and Muntz's Metal Company, Limited.

At a recent meeting of the Belfast Harbour Board the chairman announced that during the past year about 150 acres of the harbour estate had been let to shipbuilders for the purpose of extension. These lettings are situate on both the Down and Antrim sides of the river Lagan, and mean almost a doubling of the area devoted to shipbuilding and marine engineering in the port of Belfast. Of the total lettings 124 acres have been granted to Messrs. Harland & Wolff, Limited, and 24 to Messrs. Workman, Clark & Company, Limited. The Harbour Commissioners are also embarking on a most extensive scheme of harbour works (though it is not intended to proceed with the work until after the war), the carrying out of which will be spread over a considerable number of years. Parliamentary powers involving an expenditure of 2½ million pounds on these works have been obtained during the present session.

A new agency for the development of commercial relations between French producers and British consumers and to promote the sale of French merchandise in the United Kingdom has been set up under the title of "L'Office Commercial Français en Angleterre." The office has been placed under the control of the French Ministers of Commerce and Foreign Affairs, represented by the Commercial Attaché at the French Embassy in London. It is administered by a committee nominated by the French Chamber of Commerce in London, with M. Ch. E. Hauvette, Councillor of Foreign Trade, 153, Queen Victoria Street, E.C.4, as director. Four general displays of samples and models will be organised annually, and the office will be inaugurated with a special exhibition. Special displays of some one article, or of the products of one firm, or of one class of merchandise, will also be organised.

A development in stainless steel manufacture, according to the "Sheffield Daily Telegraph," is that Mr. Brearley, in association with the armament firm of Thomas Firth & Sons and Brown Bayley's Steelworks, Limited, of which he is a director, has formed a syndicate which has patents pending in practically all the trading countries of the world. Already patent rights have been secured in the United States, and in Argentine, Brazil, Canada, France, Italy, Japan and Spain. In Japan the patents have been sold to the Kawasaki Dockyard and Shipbuilding Company, and in America to the American Stainless Steel Company, in which the English syndicate is a large shareholder. The American syndicate includes the Bethlehem Steel Company (U.S. Steel Corporation), the Crucible Steel Company, Carpenter Steel Company, Firth-Sterling Steel Company, Washington Steel & Ordnance Company, and Haynes & Son. In all its foreign agreements, however, the Firth-Brearley Stainless Steel Syndicate, Limited, has had a clause inserted reserving to Sheffield manufacturers of stainless steel the right, no matter what arrangements are otherwise made for working foreign patents, to export the new steel and manufactures thereof to any part of the world, and as no patent has been applied for in this country, the syndicate's action must be regarded as a measure of broad-minded reconstruction work.

The membership of the Lancashire and Cheshire Scrap Iron, Steel, and Metal Merchants' Association now includes about eighty firms carrying on business as scrap iron, steel and metal merchants. So far, the majority of the members are firms established in Lancashire and Cheshire, but the area covered by the Association is now being extended to include the counties of Cumberland, Westmorland, Flint, Denbigh, Merioneth, Carnarvon, and Anglesey, as well as the Isle of Man. The association works with the continuous co-operation and assistance of the Scrap and Dormant Materials Department of the Ministry for the North-Western Area, whose offices are at 70, Spring Gardens, Manchester. The executive are also in constant touch with, and receive the assistance of, the Scrap and Dormant Materials Department of the Ministry at headquarters in London. The superintendent of Scrap at Manchester holds conferences in the city at intervals of about a month with the members of the association and the trade generally, to which conferences he issues an invitation to each firm. Not

the least important of the difficulties in which members receive considerable assistance from the association, and through it from the Ministry, is the retention and obtaining of valuable labour, both general and for supervision, for scrap yards. The chairman of the association is Mr. John Hart, of Messrs. Thompson & Company, Wigan. The vice-chairman is Mr. Samuel Bamber, of J. Cort, Limited, of Blackburn. The treasurer is Mr. R. R. King, of Joseph John King & Sons, Limited, shipyard, Garston. The following are also members of the committee:—Mr. R. Gildart, jun., of Messrs. R. Gildart & Sons, Blackburn; Mr. W. Lewis Holland, of Adelphi Brass Works, Preston; Mr. Geo. Howard, of Folly Lane, Warrington; Mr. John Hulbert, of Middleton, Manchester; Mr. Albert Travis, of Fairfield Street, Manchester; Mr. Wm. Kayley, of Queen Street, Ardwick, Manchester; Mr. J. Smith, of Messrs. Robert Smith and Sons, 8, Park Street, Birkenhead; and Mr. Daniel McKee, of Messrs. Maden & McKee, Limited, 317, Prescot Road, Liverpool.

Deaths.

Sir Ratan Tata, of the Tata Iron and Steel Works, Sakchi, India, died on September 5 at St. Ives, Cornwall.

Mr. John A. Innes, who died on service on September 10, was formerly a partner in the firm of Wigham, Richardson & Company.

Mr. John Boyd, founder of the engineering business of J. & T. Boyd, Limited, Shettleston Ironworks, Glasgow, has died in his 81st year.

German papers report the death of Dr. Ludwig Beck, the well-known author of the "History of Iron," at Biebrich-on-Rhine in his 78th year.

Mr. Joseph Grant, formerly proprietor of the foundry business carried on at Newgate Street Works, Worksop, died recently at the age of 67.

Mr. J. Grant, formerly proprietor of the Newgate Street Iron Foundry, Worksop, died suddenly last month. He was about 70 years of age.

The death has taken place at Abergavenny, at the age of 76, of Mr. G. Davies, Beechcroft, for many years proprietor of the Lion Engineering Works.

The death is announced of Mr. J. T. Oliver, late assistant engineer in Newcastle of the North-Eastern Railway, with which he had been connected for 56 years.

The death took place recently of Mr. R. Willis, manager of the moulding department at the works of Head, Wrightson & Company, Limited. He was 52 years of age.

Mr. John Paterson, who died at Carlisle last month, and who was in business as an iron merchant in the city, was for many years the blast furnace manager at the Derwent Works at Workington.

News has reached Birmingham of the death in hospital in France of Major A. W. Keen, eldest son of the late Mr. A. T. Keen, Harborne Park, Birmingham, who was chairman of Guest, Keen & Nettlefolds, Limited.

Lieutenant L. G. Byng, M.C., Grenadier Guards, who died of wounds on August 24, was the second son of the late Mr. G. Byng, founder of the General Electric Company, Limited. The deceased was a director of the company.

Captain John Rodgers, of Sheffield, was killed in action on September 2, on the Western front. Captain Rodgers, who was in the York and Lancaster Regiment, was the eldest son of Lieut.-Colonel John Rodgers, V.D. (retired), managing director of Joseph Rodgers & Sons, Limited, of Sheffield.

The death occurred at his residence, Carden House, Aberdeen, last month, of Mr. C. Cook, chairman of directors of Barry, Henry & Company, Limited, founders and engineers, Aberdeen. Mr. Cook, who was in his eighty-second year, had been for many years past a prominent figure in the commercial life of the city.

Mr. Caleb William Roberts, managing director of Messrs. Roberts & Cooper, Limited, iron and steel manufacturers of Brierley Hill, accidentally killed recently, was superintending boiler changing at the works, Bromley, Pensnett, when the derrick pole slipped, and let the boiler down. Mr. Roberts slipped when trying to escape, the boiler fell on him, and so severely injured him that death occurred almost immediately.

A well-known figure in North Staffordshire, Birmingham and Manchester iron and steel circles has passed away in the person of Mr. Harry Birchall, of the Goldendale Iron Company, Tunstall, at the comparatively early age of 42. The deceased gentleman, who was a victim of chest disease, was greatly respected. Under a somewhat brusque and unconventional exterior he possessed a singularly kindly disposition, and his generosity, particularly to those who needed help, was proverbial. The fortunes of the Birchall family are closely interwoven with those of the Goldendale Iron Company, for the late Mr. Birchall was associated with that concern for 26 years, while his late father boasted of half a century's connection with it.

Applications for Patents.

The names of communicators are printed in Italic type. A new number will be given when the Complete Specification is accepted.

Almfelt, K. J. Manufacturing balls for ball bearings. 14,667. September 9.

Bailey, T. F. Melting furnaces. 14,400. September 4. (United States, September 4, '17.)

Bailey, W Furnaces for melting steel, etc. 14,139. August 31.

British Westinghouse Electric & Manufacturing Company (*Westinghouse Electric & Manufacturing Company*). Moulding materials. 14,722. September 10.

Cope, F. T. Melting furnaces. 14,400. September 4. (United States, September 4, '17.)

Gibbons, F. J. J. Appliance to facilitate casting of articles in metal moulds. 14,050 August 29

Giton, A. C. Furnace for re-fusing and refining metal. 14,621. September 9.

Hall, I. Furnaces for melting steel, etc. 14,139. August 31.

Hosack, H. H. Appliances for casting metal ingots into moulds. 14,026. August 29.

Keene, A. D., Electric furnaces. 14,079. August 30. (United States September 5, 1917.)

Lord, J. Furnaces for heat treatment of metals. 14,213 August 30.

Neill, J Methods of casting steel ingots. 14,481. September 6.

Peakman, P. Determination of decalescence in treatment of steel. 14,797. September 11.

Stein et Cie, C. M. Regenerative furnaces. 14,177. August. 31. (France, September 8, 1917.)

Stein et Cie, C. M. Oscillating furnaces. 14,248 September 2. (France, October 24, '17.)

Thompson, J. A. Crucibles. 12,383. July 30.

Turner, W. L. Granulating and disintegrating aluminium, etc. 12,037. July 24.

Williams, W. A. Manufacture of armour plating. 13,429. August 19.

Woodington, J. H., and Young, C. A. Abrasive wheel. 13,446. August 19.

Young, A. G. Dies for casting metal, and process for making same. 12,206. July 26.

Legal.

Enticing a Workman.

At West Bromwich, last month, Messrs. Matthews, Purdy & Company, ironfounders, of Bradley, were fined £20 and ordered to pay 15 guineas costs, and A. E. Matthews, their secretary, was fined £10 for having induced a man to leave Messrs. Josiah Guest & Sons and enter their employment.

MOULDING MACHINES

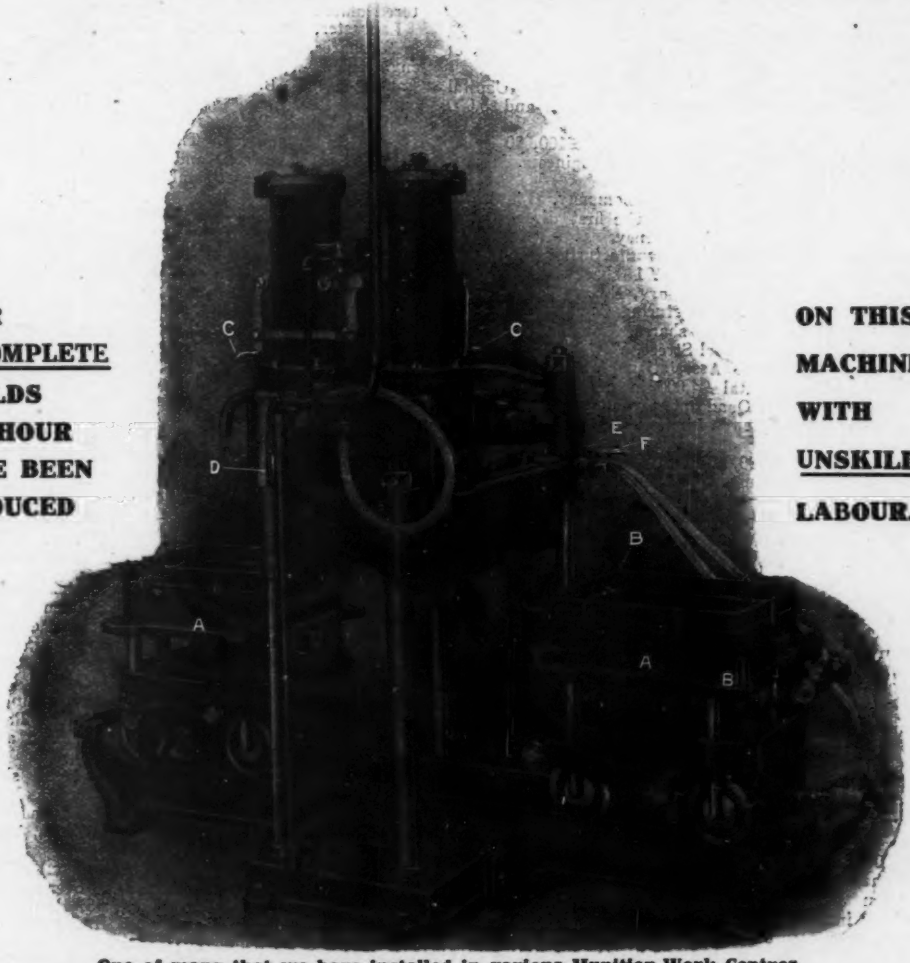
OF EVERY DESCRIPTION.

Pneumatic, Hydraulic, Jar Ramming, & Hand Power.

Type "A" Duplex Machine for Pneumatic Power.

Fitted with self-adjusting Rammer Head which accommodates itself to any varying depth of pattern.

OVER 50 COMPLETE MOULDS PER HOUR HAVE BEEN PRODUCED



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One of many that we have installed in various Munition Work Centres.

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New Companies.

Redcliffe Foundry, Limited.—Capital £1,000 in £1 shares.

Newcastle Graphite Company, Limited.—Capital £50,000 in £1 shares.

James Burley & Company, Limited.—Capital £500 in £1 shares, to carry on the business of metal workers.

Whitfield Aviation, Limited.—Capital £60,000 in £1 shares. Registered office: 14, Paternoster Row, E.C.

George Dodd & Company, Limited.—Capital £10,000 in £1 shares, to carry on the business of shipbuilders.

National Alloys, Limited.—Capital £10,000 in £1 shares. Registered office: Dock House, Billiter Street, E.C.

Star Foundry Company, Limited.—Capital £10,000 in £1 shares. Registered office: Batman's Hill Road, Coseley.

Markiew Brothers, Limited.—Capital £10,000 in £1 shares (5,000 preference), to carry on the business of toolmakers, etc.

Richmond Mechanical Works, Limited.—Capital £6,000 in 6,850 ordinary shares of £1 and 3,000 deferred shares of 1s.

Lester & Perkins, Limited.—Capital £100,000 in £1 shares, to carry on the business of engineers. Registered office: Royal Dry Dock, E.

A. G. Turney Engineering Company, Limited.—Capital £2,000 in £1 shares. The first directors are J. Ismay and A. G. Wood Turney.

British Foundry-Binder Manufacturing Company, Limited.—Capital £5,000 in £1 shares. Registered office: 5, Castle Street, Finsbury, E.C.

Ikaros Aircraft & Manufacturing Company, Limited.—Capital £5,000 in £1 shares. Registered office: Effingham House, Arundel Street, W.C.2.

Coventry Foremen's Association of Engineering and Allied Trades.—Capital £4,000 in £1 shares. Registered office: 7, The Quadrant, Coventry.

Bowling & Company, Limited.—Capital £10,000 in £1 shares, to carry on the business of ironfounders. Registered office: 100, High Street, Sutton.

E. Nash & Company, Limited.—Capital £5,000 in £1 shares, to carry on the business of engineers, etc. Registered office: Springfield Avenue, Harrogate.

Offer Engineering Works, Limited.—Capital £25,000 in £1 shares (15,000 "A" and 10,000 "B"). Registered office:—22, Union Street, Kingston-on-Thames.

G. James & Son, Limited.—Capital £1,000 in £1 shares, to take over the business of metal founders, etc., carried on by G. James & Son at Hill Top, West Bromwich.

A. W. Richardson & Son, Limited.—Capital, £10,000 in £1 shares, to carry on the business of engineers. Registered office: Skew Bridge Works, Patricroft, nr Manchester.

Cremer Aircraft & Industrial Works, Limited.—Capital £10,250 in 10,000 "A" shares of £1 and 5,000 "B" shares of 1s. Registered office: Lorn Road, Brixton, S.W.

New Metal Alloys, Limited.—Capital £20,000 in £1 shares (10,000 7½ per cent. preferred ordinary and 10,000 ordinary). Registered office:—50-52, Draycott Avenue, S.W.

Allan Jones & Company (1918), Limited.—Capital £30,000 in £1 shares, to carry on the business of metal goods manufacturers. Registered office: 10, Fenchurch Buildings, E.C.3.

D. M. Cumming, Limited.—Capital £10,000 in £1 shares to carry on the business of shipbuilders, engineers, &c. Registered office: Blackhill Shipyard, Niddrie, Glasgow.

Boneham & Turner, Limited.—Capital £1,000 in £1 shares. Mechanical, motor, electric and consulting engineers. Director: J. Boneham. Registered office: Field Mill, Nottingham Road, Mansfield.

Andrew Ness, Limited.—Capital £60,000 in £1 shares (30,000 preference), to carry on the business of engineers, contractors, etc. Registered office: 147, Cottenham Road, Upper Holloway, London, N.

Thomas Willett & Company, Limited. — Capital £3,000 in £1 shares, to take over the business carried on at the Victoria Foundry as Willett & Company. Registered office: Victoria Foundry, Burslem.

A. J. Lytheer (1918), Limited.—Capital £5,000 in £1 shares (4,000 ordinary and 1,000 founders'), to carry on the business of manufacturers of piston rings. Registered office: 16-17, Loveday Street, Birmingham.

Engine Specialists, Limited.—Capital £10,000 in 9,000 preference shares of £1 each and 10,000 deferred shares of 2s. each. Permanent directors: J. B. Taunton, M. Van Marcke de Lummen, and F. Van Bree.

Frank Trotman, Limited.—Capital £10,000 in 9,500 10 per cent. preference of £1 and 10,000 deferred at 1s. each, to carry on the business of engineers. Registered office: 58, York Street, Buckingham Gate, S.W.

Lancaster, Sons & Silcock, Limited.—Capital £5,000 in £1 shares, to take over the business of G. E. Priddle, engineer and wheelwright. The first directors are H. P. Lancaster and B. Silcock. Secretary: P. H. Lancaster.

Sheffield Ball Bearings Company, Limited.—Capital £3,000 in £1 shares. The first directors are: A. Fletcher, P. Thomson, and W. Fowler. Registered office: St. James's Chambers, 38, Church Street, Sheffield.

Oliver V. Beckerlegge, Limited.—Capital £1,500 in £1 shares. General, mechanical, and electrical engineers. Directors: O. V. Beckerlegge and Mrs. E. A. Beckerlegge. Registered office: 102, Button Lane, Sheffield.

S. J. Levi & Company, Limited.—Capital £10,000 in £1 shares, to take over the business of manufacturers of metal wares, etc., carried on at the Squirrel Works, 32-36, Regent Place, Birmingham, as S. J. Levi & Company.

Waste Metals & By-Products, Limited. — Capital £75,000 in 1s. shares. The first directors are A. M. Mandeville and A. J. Green (permanent managing directors). Registered offices: Spencer House, 4, South Place, E.C.

Edward Brierly & Sons, Limited.—Capital £25,000 in 2,000 preference of £5 each and 15,000 ordinary shares of £1 each, to carry on the business of metal merchants. Registered office: 28, Canterbury Street, Blackburn.

Coventry Aviation Company, Limited.—Capital £5,000 in £1 shares (trading as the Coventry Aviation Company), and to carry on the business of manufacturers of and dealers in aeroplanes, airships and machines, etc.

R. B. Harrison & Son, Limited.—Capital £5,000 in £1 shares, to take over the business of a ship repairer carried on by R. B. Harrison at South Bank, Bill Quay, Durham. Directors: R. B. Harrison and Mrs. A. I. Harrison.

Voucher, Limited.—Capital £7,000 in £1 shares, to take over the business of an engineer and machine tool maker carried on by H. P. Lavender as the Voucher Company at the Auto Tool Works, 65, Bridge Street, Walsall.

John Burn & Company (Birmingham), Limited.—Capital £2,000 in £1 shares, to take over the business of brassfounders, etc., carried on at 5, Henshaw Road, Small Heath, Birmingham, by W. H. Jennens (trading as John Burn & Company).

Mowll, Thorp & Company, Limited.—Capital, £1,000 in £1 shares, to act as agricultural implement makers, metal brokers, etc. The first directors are G. H. Walker and G. Drury. Registered office:—95, Pilgrim Street, Newcastle-on-Tyne.

J. & H. McLaren, Limited.—Capital £100,000 in £1 shares (30,000 preference), to take over the business of engineers carried on by J. & H. McLaren at Leeds. Directors: J. McLaren, H. McLaren. Registered office: Midland Engine Works, Jack Lane, Leeds.

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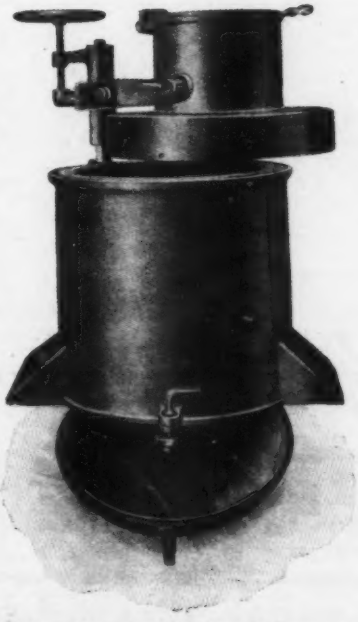
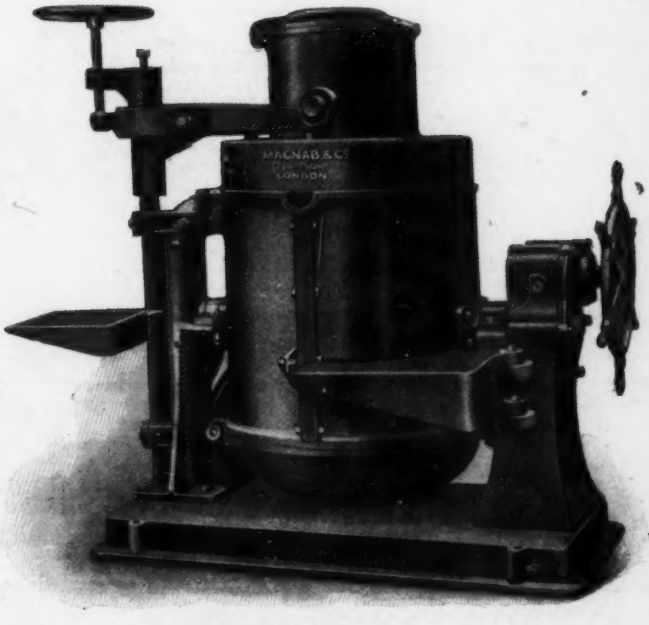
Reduce your fuel cost! Melt in a hurry!

For Brass, Gunmetal, Aluminium, Iron, etc.





Tylor Patent Pit-Type Furnace.

OUTPUT.
200 lbs. Admiralty Gunmetal melted in 25 minutes. Temperature 2000° F.

ECONOMY.
20 lbs. of Coke used per 200 lbs. of Metal melted.

STANDARD CRUCIBLES.
Lasting 35 to 40 heats.

Tilting-Type Furnace.

OUTPUT.
400 lbs. Admiralty Gunmetal melted in 45 minutes. Temperature 2000° F.

ECONOMY.
73 lbs. of Coke used per 400 lbs. of Metal melted.

STANDARD CRUCIBLES.
Lasting 35 to 40 heats.

Personal.

THE late Mr. A. Baxter, iron merchant, formerly of the Minories, E., left £41,331.

MR. M. E. UNWIN has been appointed a local director of John Brown & Company, Limited.

THE will of the late Mr. B. J. Niggermann, metal broker of Liverpool, has been proved at £8,301.

MR. T. V. ELLIS has resigned his position as managing director of Messrs. Finch's shipyard, at Chepstow.

THE late Mr. J. Wm. Cooper, Graiseley, Wolverhampton, lock manufacturer, left estate valued at £66,766 gross.

THE late Mr. A. Cochrane, head of Cochrane & Sons, Limited, Ouse Shipbuilding Yard, Selby, left estate valued at £79,794 gross.

LORD SOUTHBOROUGH and Sir Glynn H. West have been elected directors of Sir W. G. Armstrong, Whitworth& Company, Limited.

SIR DAVID HARREL, at the request of the War Cabinet, has resumed the position of Chairman of the Committee on Production.

THE late Mr. W. Richardson, retired ironfounder, of Beech Hill, Mansfield, left estate valued at £27,561, including net personalty £18,241.

THE LATE MR. J. H. ROBINSON, founder and head of the East London and Globe Foundries, Bromley-by-Bow, E., left estate valued at £16,983.

THE gross value of the estate of the late Mr. W. Booth, chairman of Joseph Booth & Bros., Limited, crane makers, Rodley, Leeds, is £46,529.

MR. JOSEPH HENRY, J.P., director of Messrs. Joseph Henry, Limited, iron and steel founders, will be the Lord Mayor of Leeds during the coming year.

THE gross value of the estate of the late Mr. J. T. Esther, of Wiggins, Esther & Company, metal merchants, Liverpool, has been returned at £5,176.

COLONEL SIR ALBERT BINGHAM, Bt., has been elected Master Cutler of Sheffield, in succession to Sir William Ellis, who has held the office for four years.

THE LATE MR. KARL ETTLINGER, of Messrs. K. Ettlinger & Company, metal and alloy merchants, Finsbury Court, E.C., left estate valued at £69,317.

THE KING has been pleased by Letters Patent under the Great Seal of the United Kingdom to degrade Sir Joseph Jonas from the degree of Knight Bachelor.

THE gross value of the estate of the late Mr. F. T. Jackson, governing director of the Coventry Radiator Company, Limited, is £49,958, including net personalty of £31,552.

MR. HENRY BROCKHOUSE has resigned his position as a director and secretary of J. Brockhouse & Company, Ltd., and has been succeeded by Mr. J. T. Brockhouse.

(*Continued on page* 556.)

Still the Premier

FURNACE MAKERS FOR MELTING, ANNEALING, HARDENING, &c. AND HEAT TREATMENT OF METALS.

OVEN FURNACES, gas, oil or solid-fuel fired. Fitted with Monometer Automatic Heat Controller.

CRUCIBLE and NON-CRUCIBLE MELTING FURNACES, gas, oil or solid-fuel fired. Tilting and Stationary Type, for STEEL, Iron, Copper, Gun-metal, Brass and all non-ferrous and ferrous metals.

HIGH SPEED STEEL FURNACE. Twin-chambered, gas or oil-fired. Even heat throughout chambers.

HEAT CONTROLLED FURNACES, for melting aluminium, lead, tin, antimony and all white metals.

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SILICO-MANGANESE { 23/30 % Silicon. / 65/70 % Manganese and 1 %, 2 %, 3 %, Carbon Maximum.

FERRO-SILICON Containing 25 %, 50 %, 75 % Silicon.

FERRO-CHROME 65/70 % Cr. & 1 % up to 8/10 % Carbon Maximum.

MAGNESIUM METAL 99 %. *In Sticks and Powder and Magnesium Copper.*

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Telephone: CENTRAL 1175 & 1176.
Birmingham Office:
18, BENNETTS HILL.

LIVERPOOL: 11, Oldhall Street. Telegrams: LATEM, LIVERPOOL. Telephone: Central 6794.

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Scotch, Middlesbro', Hematite, Basic, Specials, &c., &c.

STEEL.

Billets, Wire Rods, Tube Strip, &c.

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Tough, Best Selected and Refined Ingots, Electrolytic Ingot Bars, Wire Bars, and Cathodes.

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All Brands Ingot and Bar Tin.

SPELTER.

G.O.B.'s and Special Purities.

Telegrams: FERRUM, MIDDLESBRO'.
Telephone: MIDDLESBRO' 689.
ROYAL EXCHANGE, MIDDLESBRO'.

Telegrams: COLVIN, GLASGOW.
Telephone: CENTRAL 7460.
93, HOPE STREET, GLASGOW.

WILLIAM COLVIN & COMPANY,

MIDDLESBOROUGH AND GLASGOW.

Mr. J. R. Winskill, for many years secretary to Walter Spencer & Company, Limited, Crescent Steel Works, Sheffield, has been appointed general manager of the company.

Mr. Albert Vickers, in view of his advanced age and somewhat failing health, has resigned the chairmanship of Vickers, Limited. Mr. Douglas Vickers has been appointed chairman in his place.

The gross value of the estate of the late Mr. J. Barker, head of the firm of Messrs. Astin & Barker, of the Victoria Ironworks, Todmorden, is £12,569, including net personalty of £12,120.

Mr. Tom Birchall, younger brother of the late Mr. Harry Birchall, and assistant works manager at the Goldendale Iron Company, Limited, Tunstall, has been appointed to succeed his deceased relative.

Mr. D. G. Robertson, who has been sales manager of Messrs. George Ellison, Wellhead Lane Works, Perry Barr, Birmingham, for practically 10 years, has now been appointed assistant general manager.

Mr. E. Percy Coston, of the Liverpool University Staff, Engineering Department, who joined the Ministry of Munitions in January, 1916, as assistant inspector of munitions areas, has recently been promoted to be senior assistant inspector.

Sec.-Lieut. E. L. Williams, R.F.A., son of Mr. C. E. Williams, managing director of John Williams & Son, Limited, Globe Foundry, Cardiff, has been awarded the Military Cross and promoted lieutenant as an immediate reward for bravery in the field.

Mr. William F. Clement, who has been general works manager of the Blaenavon Company, Limited, for the last four and a half years, has been presented with a dressing-case by his co-officials, and friends, on the occasion of his leaving Blaenavon to take up another appointment.

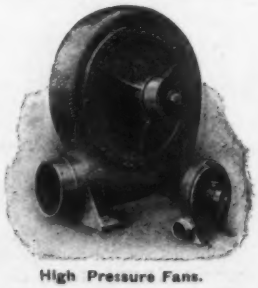
Messrs. T. Perkins, C. C. Perkins, L. O. Huggins, and R. D. Holt, M.P., are the first directors of Lester & Perkins, Limited, a company registered recently with a capital of £100,000 to acquire the engineering and shipbuilding business of Lester & Perkins, at Royal Albert Docks, London, E.

Lieut.-Col. H. M. Grayson, one of the Controllers of Ship-Repairing, and senior member of the Shipbuilding and ship-repairing firm of Messrs. H. & C. Grayson, Limited, Liverpool, has received the Order of the Crown of Italy with the Title of Commendatore for services rendered to Italy during the war.

Mr. D. J. Thomas, O.B.E., of Llanelly, has been appointed manager of the Blaenavon Steelworks. Mr. Thomas was in the employ of Richard Thomas & Company, Limited. Twelve years ago he was promoted cashier, and transferred to the South Wales Steelworks, Llanelly, where he eventually became under manager. When war broke out the firm offered the new Bury extensions to the Government, with Mr. Thomas as manager. Mr. H. Morgan, who now acts as under manager, has been appointed as Mr. Thomas's successor.

The merging of the interests of the Holwell Iron Company, Limited, of Melton Mowbray, in the Stanton Ironworks Company, Limited, near Nottingham, recently announced, will result in Mr. J. N. Derbyshire and Mr. F. Carbutt, directors of the Holwell Company, joining the Stanton board. Mr. T. Sarson, general manager of the Holwell Company, becomes general assistant to the managing director of the Stanton Company, with a seat on the board in that capacity. Mr. F. Chambers, foundry general manager of the Stanton Company, will join the board, in charge of the foundries of the two businesses. Mr. C. R. Crompton is the chairman and Mr. E. J. Fox managing director of the Stanton Company. Mr. E. Carter, secretary of the Holwell Company, will be appointed secretary of the Stanton Company.

Dust Fan.



High Pressure Fans.

Volumetric Fan.

Fans for Ventilation, for Dust Removal, for Induced & Forced Draft on Boilers.

...TRADE... SIROCCO ...MARK...

FANS

Cupola and Forge Fire Fans for large or small duties. Reliable and efficient.

Davidson & Co., Limited.,

Sirocco Engineering Works.

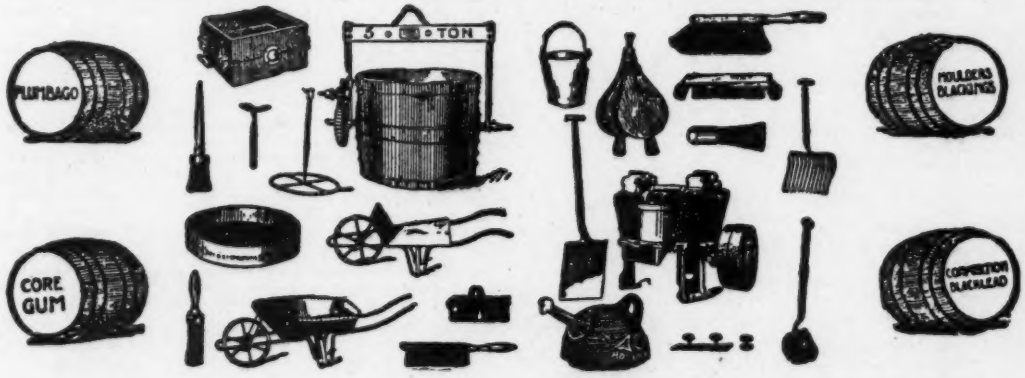
BELFAST.

Telegrams: "Durrans, Penistone." Telephone: 21, Penistone

Established 1863.

JAS. DURRANS & SONS,

Phœnix Works, Penistone, Near Sheffield.



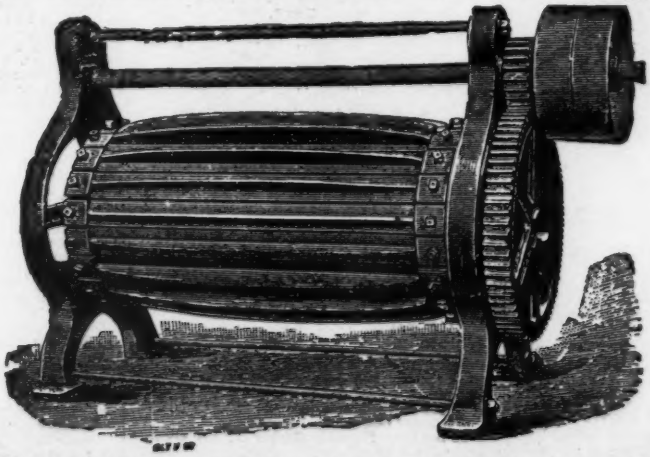
Manufacturers of all

FOUNDRY EQUIPMENTS

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Improved Foundry Rattler or Fettling Drum.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

The following testimonial explains itself :—

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD.

MONTHLY PRICE LIST.

The undermentioned prices, unless otherwise specified, are those obtaining at the commencement of the current month.

CONTROL PRICES.

Pig-Iron.

	£	s.	d.
West Coast hematite, mixed Nos. 1, 2 and 3	6	7	6
Special under 0.03 P. & S... ..	6	15	6
„ „ 0.02 „	7	0	0
East Coast hematite, mixed Nos. 1, 2 and 3	6	2	6
Special under 0.04 P. & S. ..	6	7	6
Special under 0.03 P & S. ..	6	15	6
„ „ 0.02 „	7	0	0
Scotch hematite, mixed Nos. 1, 2 and 3..	6	2	6
Special under 0.03 P. & S. ..	7	10	0
Welsh hematite, mixed Nos. 1, 2 and 3	6	2	6
Special under 0.03 P. & S. ..	6	15	6
„ „ 0.02 „	7	0	0
HEMATITE—MALLEABLE— Refined—			
Refined Cupola Cast	8	0	0
Refined Cupola Cast to guaranteed analysis..	8	5	0
Cast direct from Blast Furnaces—			
Small Pig-Iron, all grades ..	7	10	0
Medium Pig-Iron White to Grey mottled	7	5	0
Medium Pig-Iron, all other qualities	6	17	6
Large Pig-Iron, all grades ..	6	17	6
Lincolnshire, basic or foundry ..	4	17	6
Cleveland, No. 1	4	19	0
„ other grades	4	15	0
„ basic	5	0	0
Northamptonshire, forge	4	7	6
„ fdy numbers	89/0		94/0
„ basic ..	4	17	6
Derbyshire, forge	4	10	0
„ foundry numbers	92/6		96/6
Derby & Notts. basic.	4	17	6
Leicestershire & Notts., forge ..	4	10	0
„ „ foundry nos.	92/6		96/6
North Staffs, forge	4	15	0
„ „ foundry	4	17	6
„ „ basic	4	17	6
South Staffordshire—			
Part mine forge	5	0	0
„ foundry	5	2	6
Common Staffordshire ..	4	15	0
All mine forge	5	15	0
„ foundry	6	0	0
Warm air forge	7	5	0
„ foundry	7	15	0
Lord Dudley's silicon	8	7	6
Cold blast	9	2	6
Basic	4	17	6
Scotch foundry and forge—			
Nos. 3, 4, and lower grades of Monkland, Dalmellington, Eglinton, and Govan.. ..	5	14	0
Nos. 3, 4, and lower grades of all other brands	5	15	6

No. 1 quality in all cases to be 5s. per ton above these prices.

All per ton net, f.o.t. makers' works.

Mers. Com. 1½%

In all districts 1s. extra may be charged for Basic cast in chills.

High-Speed Tool Steel.

The maximum prices for high-speed tool steel have been fixed as follows:—

Finished bars, 14% Tung. 3s. 8d.

Finished bars, 18% Tung. 4s. 5d.

Per lb. basis. Extras as per authorised list. These prices are net delivered buyers' works.

The fixed prices for scrap which must be returned to steel makers' works are as follows:—

Millings and Turnings	8d.
Bar Ends	9d.

Both per lb. net delivered steel makers' works.

Ferro-Alloys

Net, Delivered Sheffield steel works.

	£	s.	d.
Ferro chrome: 4/6% carbon. Basis 60%, scale 10s. per unit Per ton	—		
Ferro-chrome: 6/8% carbon. Basis 60%, scale 10s. per unit. Per ton	—		
Ferro-chrome: 8/10% carbon. Basis 60% scale, 10s. per unit Per ton	—		
Ferro-chrome: Specially refined, guaranteed maximum 2% carbon broken to small pieces for use in best quality crucible steels. Basis 60%, scale 32s. per unit. Per ton	—		
Ferro-vanadium: 33/40% Va., per lb. of Va. contained in the alloy	—		
Ferro-silicon: 45/50%. Basis 50%, 5s. scale per unit .. Per ton	—		
Ferro-titanium: 23/25%, per lb. carbonless..	—		
Ferro-molybdenum: 70/80% Mo. per pound of Mo. contained ..	—		
Ferro-phosphorus: 20/25%. Per ton	—		
Ferro-tungsten: 75% to 80% per lb. of metallic tungsten contained	—		
*Ferro-manganese 80%	26	10	0
„ export	—		

* F.o.b. Liverpool.

Non-Ferrous Metals.

Copper.

	£	s.	d.	£	s.	d.
Standard, Cash	122	0	0	122	10	0
Three months	122	0	0	122	10	0
Electrolytic ..	137	0	0	133	0	0
Tough ..	135	0	0	131	0	0
Best selected ..	135	0	0	131	0	0

Tin.

Standard, Cash	337	0	0	338	0	0
„ Three months	337	0	0	338	0	0
English Ingots	337	10	0	—		
Bars	338	10	0	—		
Refined	—			—		

Spelter.

American ..	54	0	0	50	0	0
Specials.. ..	—			—		
Hard	45	0	0	46	0	0
British ..	56	10	0	57	0	0

Lead.

Soft Foreign (net)	29	10	0	28	10	0
English	—			Nom.		

Antimony.

Regulus	—			85	0	0

Aluminium.

Virgin Metal 98/99% per ton	—			—		

Phosphor Bronze.

INGOTS.	Per ton.
Alloy No. I. or II	—
III., IV. or V.	—
VI. or VII.	—
VIII.	—
XI.	—
Cast Strips and Ingots..	—

CASTINGS.	Per lb.
I. or II.	—
III. IV. or V.	—
VI. or VII	—
VIII.	—
XI.	—
No. VII., Chill Cast, Solid ..	—
„ Cored Bars	—

Delivery 2 Cwt. free to any town.

10 per cent. Phosphor Copper .. price of best selected copper.	£50 above
15 per cent. Phosphor Copper .. price B.S.	£70 above
Phosphor Tin (5 per cent.) .. price of English Ingots.	£30 above

(Phosphor-bronze prices supplied by CHARLES CLIFFORD AND SON, LIMITED, FAKELEY STREET MILLS, BIRMINGHAM).

***Chromium (Metallic).**

98/99% purity, per lb.	—		

***Nickel.**

In cubes, 98/99% purity Per ton	—		

Nickel Silver. per lb.

Ingots for raising	—
Ingots for Spoons and Forks ..	—
„ rolled to spoon size ..	—

***Tungsten Metal Powder.**

96/98% purity.. per lb. ..	—

***Molybdenum Metal.**

96/98% purity.. per lb. ..	—

***Cobalt Metal.**

97% purity .. per lb. ..	—

Quicksilver.

75 lb. bottle	—

* Net, Delivered Sheffield Works.

Scrap Iron and Steel.

	Cleveland. £	s.	d.	£	s.	d.
Steel scrap, heavy melting..	—			—		
Iron scrap cast (cupola metal)	—			—		
London (f.o.b.).						
Heavy steel				104	5	6
Light „				55	7	0
Heavy cast				110	0	
Control Prices.						
Heavy Steel Melting Scrap	105	0		125	0	
Steel Planings, Turnings and Borings				65	0	
Steel Planings, Turnings and Borings mixed with Wrought Iron, &c.				50	0	
Steel Scrap, all other Classes ..				95	0	
Wrought Iron Scrap				125	0	
Ditto, mixed with Steel				95	0	
W.I. Planings, Turnings and Borings mixed with Steel, &c.				50	0	

Per ton delivered Buyers' Works.

Cast-Iron Scrap.

	£	s.	d.
Hy. ord. brkn., between 1½ cwt. and 10 cwt.	4	15	0
Hy. machy., brkn., bet. 1½ cwt. and 10 cwt.	5	0	0
Cold blast, brkn., bet. 1½ cwt. and 10 cwt.	6	15	0
Ingot mould, unbroken	6	0	0
Ditto, brkn., bet. 5 cwt. and 2 tons	6	5	0
Ditto, between 1½ cwt. and 5 cwt.	6	10	0
Extra for breaking into pieces not exceeding 1½ cwt.	0	5	0
Railway chairs for re-melting ..	5	0	0
Heavy lumps, not above 2 tons ..	4	12	6
Light	4	5	0
Burnt, broken, ready for cupola ..	3	0	0
Burnt fire bars	4	0	0
Turnings and borings for iron and steel makers	3	5	0

Per ton f.o.r. or f.i.b. Scrap merchants' commission, 2½ per cent.; additional 10s. allowed, except for railway chairs and turnings and borings, to cover inwards carriage and handlings on sales from scrap yards.

Coke.

	Middlesbrough. s.	d.	s.	d.
Gas Coke	47	6	50	0
Foundry	65	0	67	6
Glasgow.				
Foundry Coke	—		47	0
Furnace Coke	37	0	—	
Gas Coke	—			
London.				
Welsh or Durham Foundry, d/d London Stations in truck	45	0	53	0
Ditto, d/d Birmingham Stations	44	0	48	0
Yorkshire, d/d London Stations, in truck	42	6	—	
Ditto, d/d Birmingham Stations	39	6		

CONTROL PRICES OF COKE.

	s.	d.
Durham and Northumberland blast furnace	33	0
„ foundry	38	0
Yorkshire, Lancashire, Staffordshire, Notts., Derbyshire, Lincs., & Midland Counties blast furnace	32	6
South Wales blast furnace ..	37	6
„ foundry	50	6
All per ton net. f.o.t. ovens.		
Cumberland blast furnace .. .. d/d West Coast furnaces	37	9

SITUATIONS VACANT AND WANTED.

TO IRONFOUNDERS and users of Steel Castings.—Crucible Steel Furnace for sale, quite simple and most economic. Advantages: (1) Low consumption of coke; (2) long life to crucible; (3) most rapid in melting; (4) little cost in starting to make steel castings; (5) tensile stress between 30 and 40 tons per sq. in.; (6) results guaranteed.—Address, Box 994, Offices of the *Foundry Trade Journal*, 165, Strand, London, W.C.2.

FOUNDRY FOREMAN requires position in general Engineering shop, 18 years' practical experience all branches of the trade; first-class testimonials, practical and theoretical; moulding machine expert, also plate and oddside, dry and green sand; good organiser, cupola practice, capable of teaching female labour; member British Foundrymen's Association; just finished three years British Expeditionary Force; North of England preferred or the Midlands.—Address, Box 996, Offices of the *Foundry Trade Journal*, 165, Strand, London, W.C.2.

PIG IRON and FOUNDRY MACHINES.—Agencies wanted for France after the War by Commercial Engineer Agent.—Please answer to DESHERCES ALBAN, 6, rue de l'Hôpital, Angoulême, Charente, France.

FOR SALE AND WANTED.

FOR SALE.—Foundry Cupola by Green Keighley, 2 ft. 9 in. diameter, used only few heats, wind belt, capacity about 30 cwts. per hour.—Address, Box 992. Offices of the FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

ROOTS' Improved Acme Blower, by Samuelson, "J" size, capable melting 3 tons per hour, suitable 20 blacksmiths' fires, excellent condition; bargain, £30.—CHAS. D. PHILLIPS, Emlyn Works, Newport, Mon.

FOR SALE as a Going Concern, a small Freehold up-to-date self-contained and well-equipped Electric Steel Foundry, complete with Generating Plant, situate within 40 miles of London. Exceptional opportunity.—Apply. Box No. 990, Offices of THE FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.2.

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MINERALS. METALS. ALLOYS.
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REFRACTORY MATERIALS and all requisites for the Engineering Trades.
Correspondence Invited.

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HEAVY RODS.—Nos. 0 to 3. Straight or in Coils Apply W. PATTISON, Widnes.

ONE MORTAR MILL, 6 ft. pan, Engine 8 in. cyl., Boiler 6 ft. 6 in. by 2 ft. 10 ins., all combined on bogie wagon; £75.—KING'S, Garston, Liverpool.

FOR SALE, Steam Derrick Crane, good, 1½-Ton, 60 ft. jib, Boiler 80 lbs. pressure, by Carrick Bros.; six Steam Winches, 7 ins. by 10 ins., by Clarke, Chapman & Co.—G. H. BLAGBURN, Tynemouth Road, North Shields.

15 TON Steam Travelling Derrick Crane, 70 ft. steel jib; 5-Ton Steam Derrick Crane, 75 ft. jib; six Hand Derrick Cranes, 30 cwts. to 3 tons; 15-Ton Steam-driven Overhead Crane, 45 ft. span; 20-Ton Square Shaft, Rope-driven Overhead Crane, 34 ft. 5 ins. span; three 3-Ton All-Steel Goliath Crane, 19 ft. 6 ins. span; 5-Ton Hand Bogie Crane, Portable, by Booth Bros.; 3-Ton Hand Bogie Portable Crane, 4 ft. 8½ ins. gauge, by Piggotts.—JOHN F. WAKE, Darlington.

T. E. MANSERGH.
EVERY DESCRIPTION OF
MOULDERS'
PATENT WOOD, MINERAL AND
COAL DUST BLACKINGS
MANUFACTURED.
Wheathill Charcoal Works, SALFORD.

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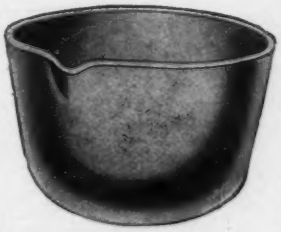
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Plain or Lipped.
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Materials and Requisites for Ironwork, Brassfounders, &c.,

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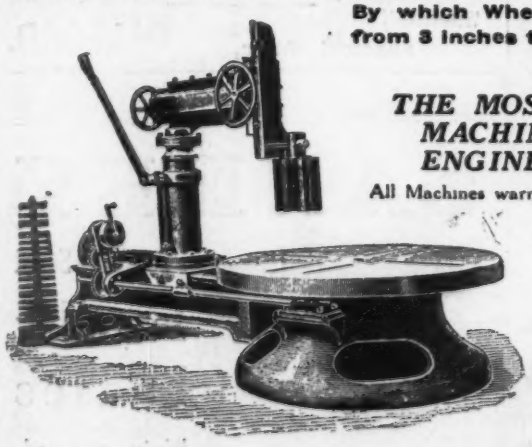
WHITTAKER'S IMPROVED MOULDING MACHINE

By which Wheels or Pulleys of any description or size from 3 inches to upwards of 20 ft. diameter can be made.



THE MOST COMPLETE AND EFFICIENT MACHINE HITHERTO INTRODUCED TO ENGINEERS.

All Machines warranted to Mould with the greatest accuracy and precision.

GEARING WHEELS

Spur or Bevel, Straight Teeth and Double Helical Teeth Supplied to Consumers.

ROPE & BELT PULLEYS.

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SUN IRON WORKS, ***OLDHAM.***

CAPPONFIELD

BILSTON.

Special Pig Iron

We can meet your requirements in

SPECIAL

Foundry Irons

CAPPONFIELD BRANDS.

C.A.M.	All Mine
C.C.B.	Cold Blast
ZENITH	Refined

Thomas & Isaac Bradley, Ltd.,
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— BILSTON. —

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"FOUNDRYMEN have been seeking this material for years."

Supplied only in 40 gallon Casks. No bulk broken.

FOUNDRITE is another German speciality superseded and improved.

FOUNDRITE is the binding material for moulding sand and cores.

FOUNDRITE SUPERSEDES and makes unnecessary all classes of **CORE GUM, LINSEED OIL and all other BINDING material.**

FOUNDRITE will renew old and burned sand, making it usable over and over again.

FOUNDRITE makes **CORES** unbreakable and the use of **core irons** unnecessary.

FOUNDRITE leaves **CORES** perfectly porous and does **not shrink.**

FOUNDRITE has been **"found right"** for all **Sand binding** in the Foundry **for all purposes.**

FOUNDRITE is supplied in **LIQUID** form ready for use. Dilute with Water.

The porosity of the core is perfect, and cores so made do not shrink.

No blowing, cracking, crumbling, honeycombing, or loss of strength can take place.

COST OF USING "FOUNDRITE."

For ordinary work the price is about One Penny per gallon.

FOUNDRITE is used in all important Foundries in Great Britain and the Continent.

FOUNDRITE SAVES MONEY.
FOUNDRITE PREVENTS WASTERS.

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FOUNDRY EXPERTS.

FOUNDRY CUPOLAS, LADLES,

And the

OSBORN'S PATENT CUPOLA

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RAILWAY WORKS,

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MAKERS OF THE CELEBRATED BLACKHEART MALLEABLE CASTINGS.

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FURNISHERS
AND
FOUNDRY REQUISITES
Of every description.

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"The Dressing of Chill-Moulds"

FOR STRIP, BAR & BILLET CASTING.

Sent free of charge to Metal Manufacturers, &c.

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REGENERATIVE GAS

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FOR MAKING MALLEABLE IRON AND STEEL CASTINGS.
CONTINUOUS ANNEALING FURNACES FOR ALL PURPOSES.

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JOHN R. FYFE & CO.,

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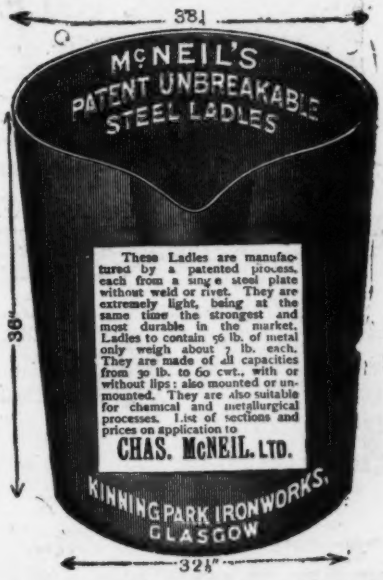
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PATENT UNBREAKABLE
STEEL LADLES
These Ladles are manufactured by a patented process, each from a single steel plate without weld or rivet. They are extremely light, being at the same time the strongest and most durable in the market. Ladles to contain 56 lb. of metal only weigh about 7 lb. each. They are made of all capacities from 30 lb. to 60 cwt., with or without lips: also mounted or unmounted. They are also suitable for chemical and metallurgical processes. List of sections and prices on application to
CHAS. McNEIL, LTD.
KINNING PARK IRONWORKS,
GLASGOW
36"
32½"

CAN ALSO BE MADE IN ALUMINIUM.

Kindly mention this paper when enquiring or ordering

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THE CONSTRUCTIONAL ENGINEERING CO.,

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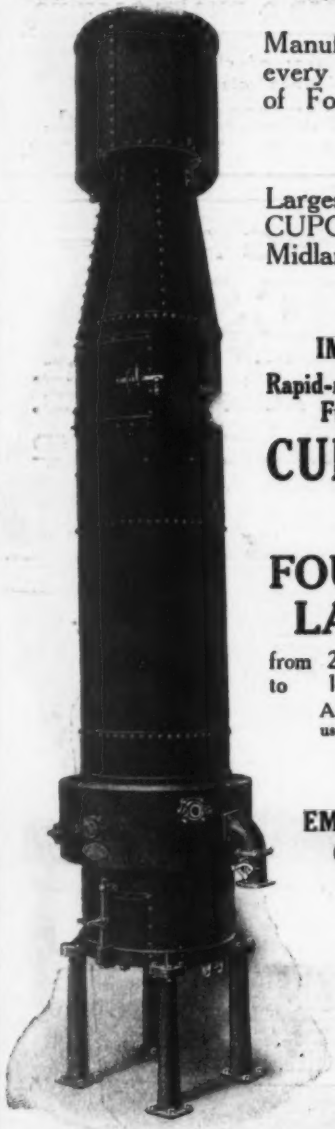
Telegrams: "Structural, B'ham. Telephone: Midland 2182.



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Largest Makers of CUPOLAS in the Midlands.

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Rapid-melting
Full-economising
CUPOLAS.

FOUNDRY LADLES

from 28 lbs. capacity
to 10 tons ,,
A large number usually in stock.

EMERGENCY CUPOLETTES.

Also Makers of
Charging Platforms,
Shaking Barrels,
Hoists, Cranes,
Runways, etc.

From Plans of No. 4 Cupola complete with Tank-form Spark Arrester.
Made in all sizes from ¼ ton melting capacity to 15 tons per hour.

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CHARLES HENRY STREET, BIRMINGHAM.

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CUPOLA BRICKS.

Best Quality.

LESSEES OF DELPH AND TINTERN ABBEY BLACK AND WHITE CLAY.

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(STOURBRIDGE) Ltd.,
STOURBRIDGE.

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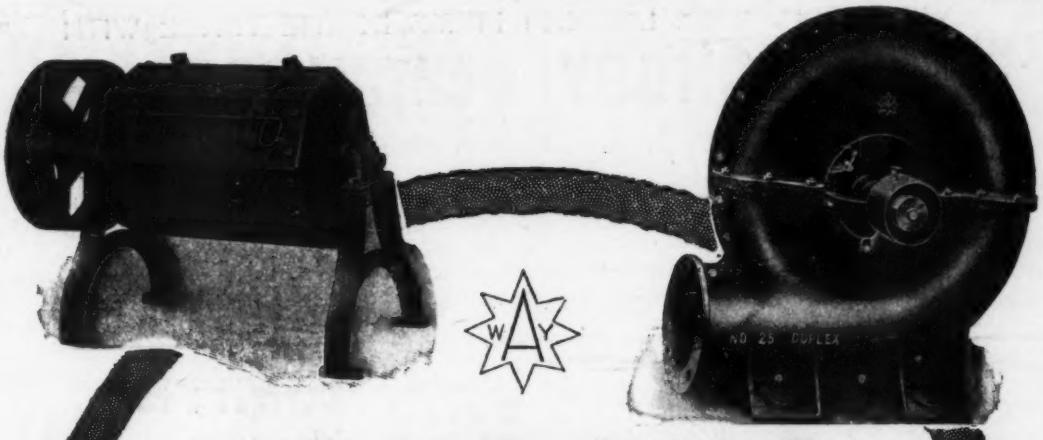

ALLDAYS

FOUNDRY REQUISITES

The accompanying illustrations give but a brief idea of the wide range of Foundry Equipment made by us, which includes:—

BLOWERS, CRANES, CUPOLAS, FANS, MELTING FURNACES (oil, gas and coal fired), LADLES, SAND MIXERS, SMALL TOOLS, Etc., Etc.

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Our Specialite is Studying Special Requirements.
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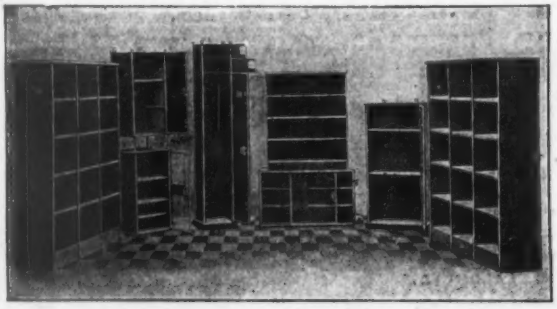
(KENT HOUSE STATION).



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Gas Fired DRYING STOVES, ANNEALING OVENS, &c.
NO SMOKE. SAVING 50 per cent.
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FIRST AID OUTFITS

in all Metal Foundries.

MAY, ROBERTS & CO., Ltd.

can tell you exactly what is required of you under the Order and can supply you with the means of complying with it.

SIZE B.

CONTENTS OF CABINETS.

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Suitable for 50 or less Workers. Polished Wood Case. Size 9 × 6½ × 6½ ins.

1 Copy First Aid Leaflet (H.O. 923).
1 „ First Aid Instructions.
3 dozen Small Sterilized Finger Dressings.
1 dozen Medium „ Hand and Foot Dressings.
1 dozen Large „ Body Dressings.
1 Bottle No. 1 Eye Drops.
3 Packets Sterilized Cotton Wool.
1 Notice Card for Factory use.

21/- Each.

3 or more, 20/- each. 6 or more, 19/6 each.

All Dressings are Sterilized and in Cartons.

Size "A" CASES are fitted with the MINIMUM REQUIREMENTS UNDER THE ACT

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Suitable for 150 or less workers. Polished Wood Case. Size 13 × 11 × 7 ins.

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3 dozen Small Finger Dressings.
3 „ Medium Hand and Foot Dressings.
1 „ Large Body Dressings.
1 „ Small Burn „
½ „ Med. „ „
½ „ Large „ „
½ „ Sterilized Eye „
1 Bottle No. 1 Eye Drops.
1 Bottle No. 2 „ „
1 Dredger Bicarbonate of Soda.
½ dozen Sterilized Cotton Wool.
1 Box Assorted Water Dressing Bandages.
2 only Triangular Bandages.
1 Box Iodine Ampoules.
1 Spool Adhesive Plaster.
1 Pair Dressing Forceps.
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Full information free—to save time send us your order.

NO EXPERIMENTS. NO SPECIAL EQUIPMENT. NO PATENT TUYERES OR FLUXES REQUIRED. JUST COMMON SENSE IDEAS.

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WITH
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A SPECIALITY.
THE "BRADFORD" PATENT
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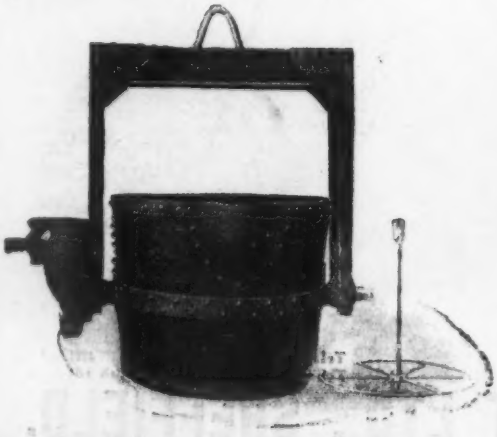

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The Handiest and Cheapest Barrow in the market. Specially designed for coal, dross, ashes, etc. Its capacity is 25 per cent. greater than the ordinary style, yet it can be wheeled with half the labour, and can be emptied much more quickly. It is a perfectly balanced barrow, and a full load can be easily wheeled by a boy.

NOTE.—This Barrow can be taken right up to mouth of furnace and the ashes drawn into the barrow direct from the furnace.

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BRABY for high grade STEEL
SHEETS and PLATES up to 15 FEET LONG.
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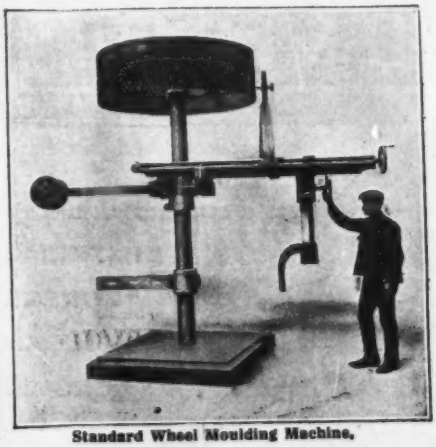

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ALL IRON AND STEEL FOUNDRIES

SHOULD BE EQUIPPED WITH

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Complete
Satisfaction
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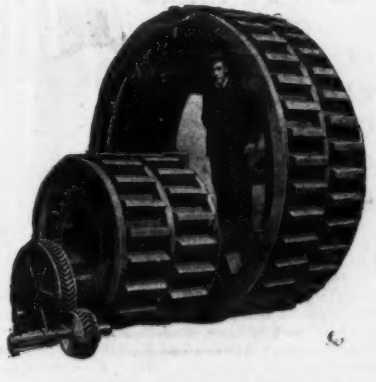

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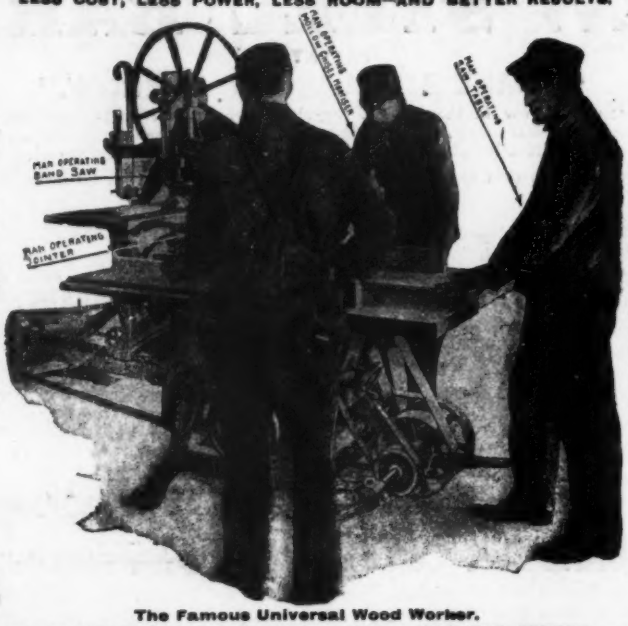

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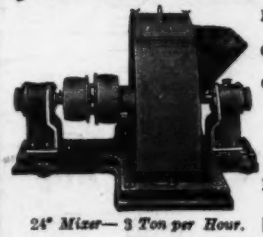

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